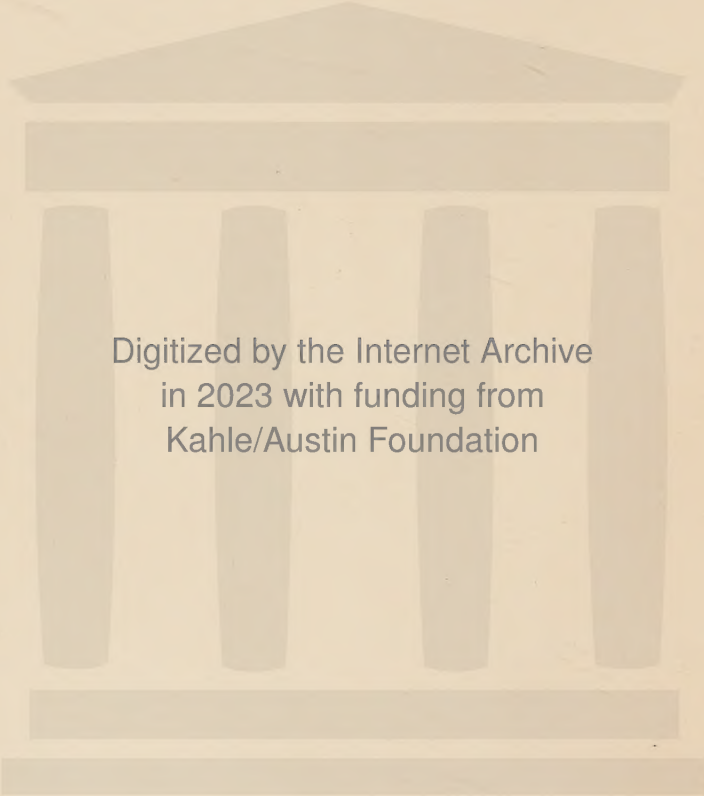




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COTTON AND ITS PRODUCTION



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COTTON

AND ITS PRODUCTION

BY
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WITH AN INTRODUCTION BY
SIR WYNDHAM DUNSTAN

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PRESIDENT, INTERNATIONAL ASSOCIATION FOR TROPICAL AGRICULTURE,
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AND A FOREWORD BY
SIR WILLIAM HIMBURY

MANAGING DIRECTOR OF THE BRITISH COTTON GROWING ASSOCIATION

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INTRODUCTION

I AM glad to comply with the request that I should write an Introduction to this important book, which appears at a time when renewed attention is being given to the problem of securing a far larger supply of a commodity which is of first importance, not only to the principal manufacturing industry of this country, but to the entire world.

It is satisfactory to notice the great progress which has been made in dealing with the question since 1904 when, at the request of the Government, I wrote the first official report on the general subject of Cotton Cultivation in the Empire (*Cotton Cultivation in the British Empire and in Egypt*, Cd. 2020, 1904), which was followed by a series of other similar reports published by Government and by the International Association for Tropical Agriculture (*British Cotton Cultivation*, Cd. 3997, 1908 ; *The Present Position of Cotton Cultivation*, Paris, 1910 ; *Reports and Papers on Cotton Cultivation*, Paris, 1911).

At first a conspicuous weakness in the effort to develop cotton growing within the Empire was the absence in the Colonies and Protectorates of well-equipped Agricultural Departments able to afford information and advice and also to conduct the essential preliminary experimental work. In many places these did not exist, whilst in others there was nothing beyond a Botanical Garden.

It was necessary, again and again, to enforce the point that there could be little real progress until this deficiency had been remedied. This has now been done, and in all the Colonies and Protectorates there are efficient Departments, which are likely to grow in size and importance and to

render invaluable help to the development of cotton growing and to its maintenance on a permanent footing in a system of agriculture.

The British Cotton Growing Association deserves the greatest credit in connection with recent developments in cotton growing within the Empire. As Sir William Himbury shows in his Foreword, this has been largely a voluntary movement assisted from time to time by Government grants, carried on through good times and bad, which has done more than anything else to bring about the present satisfactory era of activity and enterprise in this important matter.

With the aid of a grant of one million pounds sterling made by the Government and a compulsory levy on imports of cotton, the Empire Cotton Growing Corporation is devoting attention to the training of experts on the various aspects of cotton growing with a view to their attachment to the Agricultural Departments of those countries which require expert assistance. The Corporation is also giving advice and assistance in other matters, directly or indirectly connected with cotton growing, including agricultural implements and machinery for transport.

Earlier efforts to encourage cotton cultivation have usually been checked by a fall in the market price, and in many cases cultivation has fallen into abeyance. This situation may recur. In this connection it has to be borne in mind that in those countries, and there are several, in which we depend on natives to cultivate cotton on their own account, it may happen that the price of cotton is such that other crops may prove to be more remunerative to the grower, and that unless a temporary subsidy is considered expedient, cotton cultivation may be abandoned. The growth of cotton in many countries under varied conditions will diminish the risk of this position.

The possibility of the artificial production of cotton, or of an efficient cotton substitute, from an abundant raw

material such as wood, cannot be entirely discounted. The production from wood of the useful fibre, wrongly known as "artificial silk", will probably diminish to some extent the use of cotton for certain textile purposes, and it is not impossible that a fibre more nearly resembling cotton may be produced artificially by similar means. In such an event the crucial point will be cost of production. So long as cotton can be grown at a low cost, no substitute is likely to be a successful competitor with it for ordinary textile purposes.

The possibilities of each country of the world for the production of cotton are now fairly well known, and it is very desirable that there should be some authoritative record of the facts, such as is now supplied by Mr. Johnson's book, which will prove of value, not only to those interested in the growth of cotton in the British Empire and elsewhere, but also to those concerned with its industrial uses.

As Mr. Johnson shows, great efforts are being made to increase the production of cotton within the British Empire where there are still large areas suitable for the growth of the plant and which only need adequate labour and transport facilities to make the production of cotton a commercial success. Considerable advances have been made in recent years, but the Empire's contribution to its own cotton requirements is still very small, less than 10 per cent of a total of which 75 per cent is derived from the United States, which is the greatest producer of cotton in the world. The United States is, however, not only a cotton-producing country, but also a cotton-manufacturing country on an increasing scale. At the present time already more than 60 per cent of the American cotton crop is retained for use in America. The growth of cotton in the United States is not likely to be much further expanded, and therefore in order to meet the world's demand for an increased supply of cheap cotton, other fields of production must be developed. In dealing with this problem England is vitally concerned, mainly on account of the large cotton-manufacturing industry

of Lancashire, and it is clear that in order to meet the demand for more cotton, which is immediate, efforts to extend cotton cultivation within the Empire will need to be supplemented by similar activities in all parts of the world in which the growth of cotton is possible.

Among the more promising areas for large developments are India and the Sudan, within the Empire, and Brazil and other states in South and Central America. There are also considerable areas in South Africa and Australia where substantial progress will depend on the supply and cost of labour and on other economic conditions which are difficult to forecast at present. Both Asia Minor and Mesopotamia offer large fields for cotton growing, but no great progress can be looked for until political conditions are settled.

Mr. Johnson explains the present position and prospects of cotton cultivation in every country in which there is any chance of success, and his book furnishes the most complete guide and encyclopædia which has yet appeared.

WYNDHAM R. DUNSTAN.

FOREWORD

ON THE WORK OF THE BRITISH COTTON GROWING ASSOCIATION

OF the plants which minister to the material needs of man, cotton occupies an important position, and as the question of the regular supply of cotton is to-day one of the most urgent industrial problems in this country, I heartily welcome the advent of Mr. Johnson's book, which contains a mass of most useful information for all interested in cotton growing. He has treated the subject very thoroughly, and my only object in penning this Foreword is to give the reader some insight into the history and progress of the British Cotton Growing Association, which for nearly a quarter of a century has done much to augment Empire production. The origin of this Association is to be found in a systematic attempt to deal with the recurrent problem of a cotton shortage in Lancashire, by opening up new fields of cotton production within our Empire.

The unsatisfactory position as regards the supply of raw cotton for Lancashire led to the formation of the Association in 1902 in consequence of the action taken by the Oldham Chamber of Commerce in 1901. As a first step, at the request of the newly formed Association, the Colonial Office sent despatches to various British Colonies and Protectorates, requesting information as to the possibilities of cotton growing. The results of these inquiries were so encouraging that it was decided to place the Association in a strong position to co-operate in further action. A meeting

took place in February 1902, at which all the Associations of employers and employed as well as the Chambers of Commerce of Lancashire were represented. Subsequently a Royal Charter was granted to the Association in 1904 and the capital was increased to half a million sterling. To raise this amount large firms connected with the trade subscribed, as also did the various operatives' Associations and Co-operative Societies as well as many individual operatives. The Council of the Association was thoroughly representative of all branches of the trade, and included both masters and operatives' leaders. Sir Alfred Jones, K.C.M.G., was chosen as the first President, and he rendered invaluable service to the cause. On his death in 1909 the Earl of Derby, K.G., was elected as his successor, and he is not merely a figure-head, but a very hard worker on behalf of the Association. The object of the Association was primarily to promote by various means the production of cotton within the British Empire. Since its formation the Association has conducted cotton-growing investigations in every country in the Empire where there appeared to be a reasonable prospect of cotton of good quality being produced on a commercial scale.

The Association commenced its operations in West Africa by engaging a number of experts from the United States of America, and these experts paid visits to various West African Colonies to select suitable areas and initiate cotton-growing experiments. Large areas were acquired and put under American cotton on the plantation principle with native labour, but it was eventually found that this method was not likely to succeed under West African conditions; and therefore the policy adopted was to encourage cotton growing as an industry to be conducted by the native on his own land, the Association establishing and maintaining experimental farms for the raising and improving of seed for distribution with a staff to give information and advice. There were then no properly equipped Agricultural Departments to undertake any of this work, although subsequently

such departments were formed by the Government which took over some of these duties from the Association. As the work developed it was found essential to concentrate efforts on those districts which offered the best prospects of success in the immediate future, and the Association therefore discontinued operations in those places where developments could not be expected within a reasonable time even under the most favourable conditions, or where, owing to the lack of transport, substantial progress was for the time being out of the question. Sierra Leone, the Gambia, and the Gold Coast among the West African Colonies eventually came under this heading. Determined efforts were continued in Nigeria, Uganda, Nyasaland, the Sudan, West Indies, and in more recent years South Africa, Northern and Southern Rhodesia, and since the Armistice in the Punjab, and in the Mandated Territories of Tanganyika and Iraq, with the result that by progressive stages in all those countries, substantial results have been achieved, as the following figures will prove. In 1912 the approximate estimate of cotton grown in new fields in the Empire amounted to 71,490 bales. In 1921 the figures had increased to 165,200 bales, and in 1924 had reached 261,900 bales. In addition there has been an increased production of 200,000 bales of improved long stapled cotton in the Punjab during 1923 and 1924.

From the inception of the Association great help to the movement was rendered by the Imperial Institute under the guidance of Professor, now Sir Wyndham Dunstan, with its staff of experts. It is further worthy of mention that the first of Sir Wyndham's numerous reports on the prospects of cotton cultivation in the British Empire, which was issued as a Government Blue Book in 1904, attracted great attention, and was followed by the first Exhibition of Empire-grown cotton at the Imperial Institute, in which the British Cotton Growing Association co-operated, and which was opened by H.M. The King, then Prince of Wales.

The scientific and technical Department of the Institute has throughout conducted numerous investigations and prosecuted inquiries into the quality and defects of the cotton grown in experimental areas throughout the Empire. The Institute also greatly assisted in the formation of Agricultural Departments in the various Colonies, and in the selection of officers to be appointed to them.

In 1904 it had been agreed that the Governments of Sierra Leone, Lagos, and Southern Nigeria should contribute grants of £1500, £2000, and £3000 per annum respectively for three years towards the cost of the Association's work in those countries. These grants expired on March 31, 1907. By that time it had been decided to abandon operations in Sierra Leone, where there seemed no reasonable prospect of establishing the cotton industry on any considerable scale.

It was then arranged that for a period of three years from April 1, 1907, Northern Nigeria should contribute £1000 per annum and Southern Nigeria £5000 per annum towards the cost of the Association's work. Furthermore, from this period an arrangement was in force in the East Africa Protectorate (now Kenya) similar to that in West Africa, whereby the Government of the Protectorate contributed £1000 a year towards the cost of the experimental work of the Association on certain conditions.

In 1910 a new grant was given by the Imperial Government of £10,000 a year to the Association, which was renewed in 1913 for a further period of three years, towards the cost of pioneer work which the Association was then conducting. This grant from Imperial funds expired on March 31, 1916, when it was discontinued, although a grant of £1000 per annum was given for one year more, and since then the Association has received no monetary assistance from the Imperial or Colonial Governments, and the whole of the operations have been conducted with its own funds.

A great deal of time was thus spent in the attempt to discover and develop these new areas within the Empire

which would ultimately increase the supply of cotton and much valuable information gained. It was of course impossible to expect large results for some considerable time, because in addition to preliminary trials which required time, there was a total lack of transport in some of the most promising regions. Railways had to be built in West and East Africa, and in countries where there were possibilities of irrigation, barrages and other large works had to be planned and constructed. After a period of satisfactory progress the Great War intervened, and at least five years of valuable work were lost; but from small beginnings in 1903, when 1900 bales were produced in the British Empire excluding India, more or less directly under the auspices of the newly formed Association, a total of 261,900 bales had been reached in the year 1924. During that time the Association in those countries where it has been operating has extended its pioneer work and has established buying stations and up-to-date ginning factories for the handling and marketing of the crop. In some Colonies and Protectorates considerable sums have been advanced to planters, whilst in other countries a fixed price for the seed cotton has been guaranteed for the crop, either before or after harvesting. Large quantities of seed for planting purposes have also been distributed free of charge, and in many other directions help to foster the cotton-growing industry has been given. The Association also renders assistance by making advances against shipments, and attends to the sale of the crops when grown, if consigned to the Association, in return for a small commission. The Association also gives expert advice as to the right type of cotton to grow, and the best method of procedure. Reports on cotton samples are also furnished, and the ordering of machinery, plant, baling material, etc., etc., is attended to by a specially qualified department.

The magnitude of the task which the Association had set itself to accomplish for the whole Empire, and the very heavy responsibilities thrown upon its officials at the outbreak

of the War proved to be excessive. In 1917 the Association, with representatives of the leading cotton interests, placed their difficulties before H.M. Government with the request that a special committee should be appointed to consider the whole question. The then Prime Minister (Mr. Lloyd George) received the proposals sympathetically, and, through the Board of Trade, appointed a committee, of which Sir Henry Birchenough was the chairman, "to investigate the best means of developing the growing of cotton within the Empire, and to advise the Government as to the necessary measures to be taken for this purpose". After interviewing many witnesses, including Government officials and others familiar with cotton growing in practically every part of the Empire, as well as representatives of various organisations interested in securing an adequate supply of cotton, this committee issued its final report in January 1920. This report, which contains most comprehensive and exhaustive information, includes a recommendation that a permanent organisation should be set up to carry into effect the far-reaching proposals of the committee for promoting the growing of cotton within the Empire. The Empire Cotton Growing Corporation is the result of this recommendation. The Corporation received a grant of nearly one million pounds sterling from H.M. Government, and a Bill was afterwards passed through the House of Commons making it compulsory for the cotton trade to pay towards the funds of the Corporation a levy of 6d. per standard bale on all cotton purchased by spinners in this country. With these funds the Corporation undertake the training of experts to be attached to the Agricultural Departments of the Colonies. Research stations are established and a great deal of propaganda work is also done. The Corporation, however, has only been at work for a few years, and it will take some time before substantial results can be shown.

It may therefore be said that the Empire Cotton Growing Corporation and the British Cotton Growing Association now

divide the ground of promoting cotton production within the British Empire ; the sphere of the Corporation being chiefly educational and that of the Association chiefly commercial.

The British Cotton Growing Association owes very much to those early pioneers, and especially to Sir Alfred Jones, whose unfailing energy and courage stimulated and went so largely to bring about what has undoubtedly proved to be one of the best examples of successful Imperial development ; in which both Capital and Labour in one of Britain's largest industries have participated. Of the large Council who have worked for many years without personal reward, many of whom have now passed away, it would be invidious to mention names. The name of Mr. J. Arthur Hutton, who happily is still with us, and who acted as the chairman of the Association for so many years, cannot be omitted from any account of the British Cotton Growing Association. Of those who have gone, Mr. B. Crapper, and, from the Operatives' side, Mr. William Marsland, although busy men, were not only willing to serve on the Council, but to go and investigate for themselves the possibilities of cotton growing in the West Indies, the Sudan, and Iraq. The late Sir Ralph Moor, formerly Governor of Southern Nigeria, after his retirement gave the Association much help. Lancashire will always be greatly indebted to these men, and to the original and present members of the Council of the British Cotton Growing Association, who at the cost of valuable time and strenuous effort gave and are giving of their best to the first serious and sustained effort which has ever been made to develop cotton growing within the Empire.

W. H. HIMBURY.

AUTHOR'S NOTE

MUCH of the information given in this book was collected during the twenty years in which I had charge of Agricultural Departments in West and East Africa, and during my travels in Ceylon, South Africa, Rhodesia, Australia, and the United States of America.

To the various authorities on cotton to whom I am indebted for assistance in the compilation of this work, I must first and foremost express my gratitude to Sir Wyndham Dunstan, K.C.M.G., LL.D., M.A., F.R.S., formerly Director of the Imperial Institute, who, since I commenced writing it more than three years ago, has helped me with advice, and has ungrudgingly devoted his time to reading the manuscript and offering many valuable suggestions in regard to it.

To Sir William Himbury, Managing Director of the British Cotton Growing Association, I am likewise indebted for reading the manuscript, and for valuable suggestions and much useful information.

I am further indebted to these two gentlemen for respectively writing the Introduction and Foreword.

Dr. W. A. Taylor, Chief of the Bureau of Plant Industry, United States Department of Agriculture, has very kindly supplied me with a large number of publications pertaining to cotton, which have been published from time to time by the United States Department of Agriculture.

To Dr. Arthur W. Hill, M.A., F.R.S., Director of the Royal Botanic Gardens, Kew, and Dr. W. Lawrence Balls, F.R.S., Chief of the Experimental Department, Fine Cotton

Spinners' Association, I am indebted for references to publications relating to the botany of the cotton plant.

To the Library Staff of the Imperial Institute, and more particularly to Mr. H. J. Jeffery, A.R.C.S., Librarian, I am deeply grateful for their generous and willing aid in tracing information about numerous cotton matters in the Imperial Institute Library.

The principal publications that I have consulted are included in the Bibliography.

W. H. JOHNSON.

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CHAPTER I

HISTORICAL

Cotton in India, 800 B.C. — Cotton in Arabia in first century — Early records of India's cotton commerce — High quality of early Indian cotton goods — China — Egypt — Europe — Africa — Japan — The New World — Mexico — Brazil — United States of America — Development due to invention of saw gin — World's cotton crop at end of eighteenth century — Early efforts to develop Indian cotton industry — Great Britain's cotton imports — Development of the cotton manufacturing industry — Early manufacture of Flemish fustians — Origin of English cotton industry — Cotton duties — Regular imports of American cotton commenced — Beginning of English cotton export — Inventions of cotton machinery — Rapid growth of English cotton industry — Development of American cotton manufacturing — World's cotton spindles — The world's cotton crops — Cotton prices — The world's consumption of cotton — The world's chief centres of production and consumption.

THE English word cotton has its derivation in the Arabic *kutn*, *katān*, or *kutun*, which originally had reference to flax and not to cotton. Cotton consists of the floss or down that is produced on the seeds of certain Malvaceous plants.

Considering the enormous importance of cotton in the world's commerce to-day, it seems incredible that Western civilised nations were almost ignorant of its existence only two hundred years ago. Cotton is the cheapest textile, and no satisfactory substitute for it has yet been discovered. Five times more cotton than wool is used for clothing ; indeed it is estimated to provide material for nine-tenths of the clothing of the world's inhabitants. Moreover, it is considered that, out of a total population of about 1,650,000,000, probably only one-third are completely clothed, one-half are partially clothed, and the remainder are scarcely clothed at all. Cotton goods constitute the chief of all the exports from the British Isles. It is estimated that there are to-day in this country three millions entirely dependent on cotton for means of livelihood, while ten millions are affected by it.

Cotton in India, 800 B.C.—The earliest historical records mention the art of weaving various fibres for cloth manufacture. In Palestine, Greece, Italy, and Spain wool was in most general use, in China silk, hemp in Northern Europe, flax in Egypt, and cotton in India. In the ancient digest of the institutes of Manu, which were written in 800 B.C., cotton receives mention, and in such a manner as to show that the Hindoos must have been familiar with it for generations.

Woven cotton cloths had been brought to Europe, and had become a marketable commodity, long before there was any precise information as to the fibre of which they were manufactured.

The first knowledge that the Greeks obtained of cotton was from the explorers who accompanied Alexander the Great to India, 327 B.C. On this expedition the Greeks used cotton to stuff their horses' saddles, and to pad their clothing.

The earliest description of Indian cotton cultivation is given by Theophrastus, 350 B.C.: "The trees from which the Indians make cloth have a leaf like that of the black mulberry, but the whole plant resembles the dog rose. They set them in plains arranged in rows so as to look like vines at a distance."

Cotton in Arabia in First Century.—Pliny, first century, also mentions the cotton plant in India as having leaves like the mulberry, which is sowed in the field, and from which the natives make their clothes. In addition he mentions that cotton cultivation may be seen also in Arabia, and states: "In Upper Egypt, towards Arabia, there grows a shrub which some call 'gossypion' and others 'xylon', from which the stuffs are made which we call 'xylina'. It is small and bears a fruit resembling the filbert, within which is a downy wool, which is spun into thread. Nothing is more to be desired than this goods for whiteness and softness. Garments are made from it which are very acceptable to the priests of Egypt."

The island of Tylos, near the Arabian coast in the Gulf of Persia, produced cotton in ancient times, for Theophrastus describes wool-bearing trees which grew abundantly in the island, with leaves like but smaller than those of the vine, and with capsules about the size of a quince, which burst

when they were ripe exposing the seed enveloped in a wool, from which cloths were woven by the people.

Early Records of India's Cotton Commerce.—Accounts are extant of India's cotton growing and manufacturing activities at the birth of the Christian era. The *Periplus of the Erythraean Sea*, A.D. 63, gives the first mention of Indian cotton commerce. The raw cotton and the Indian cotton manufactures were taken by the Arabs from "Patiala, Ariake, and Barygaza" up the Red Sea to "Aduli". It is therefore evident that at this period the Hindoos not only produced and manufactured sufficient cotton for their own needs, but for export to other places as well.

In his *Indika*, Arrian, A.D. 150, states that the cotton of India is whiter and brighter than that of any other country.

High Quality of Early Indian Cotton Goods.—India continued to be the centre of the cotton industry for many years. It was not until the last century that cloths, equal in quality to those manufactured in India with the most primitive appliances, were produced elsewhere. Some of their muslins also had the most extraordinary delicacy of texture. Tavernier states in *Harris's Collection of Voyages*: "Some calicuts are made so fine you can hardly feel them in your hand, and the thread when spun is scarce discernible"; also "the rich have turbans of so fine a cloth that thirty ells of it put into one turban make it weigh less than four ounces". Ward (*View of the History, Literature, and Mythology of the Hindoos*) relates that "when the muslin is laid on the grass to bleach and the dew has fallen on it, it is no longer discernible". It is therefore not surprising to find the poetic scribes of the Orient describing these fabrics as "webs of woven wind". A translation of the journal of an Arab, Sulaiman, who visited India and China in the ninth century, in a description of the town of Calicut states: "Garments are made in so extraordinary a manner that nowhere else are the like to be seen. They are for the most part round, and woven to that degree of fineness that they may be drawn through a ring of middling size."

It is interesting to note that, in 1816, the cotton weavers of Bengal exported calicoes to the value of £1,659,994.

China.—Sulaiman specially mentions that the Chinese were dressed in silk, but he makes no reference to cotton in

China. Cotton was introduced into China from India about the time of the conquest of the former country by the Tartars, but does not seem to have been cultivated in China for its fibre until the fourteenth century. There would even appear to have been as much resistance to its introduction as a textile to China and Japan as was later experienced in Europe. This antipathy to its use in early times is in marked contrast to the position to-day, for it is now even more extensively used in these two Eastern countries than it is in the West.

Egypt.—The Arab physician Abdullatiph, who paid a visit to Egypt in A.D. 1200 and published a description of the plants that he saw, does not mention cotton. Pliny, however, in an account of Aethiopia, refers to cotton plants growing in the region adjacent to Egypt, which yield a more woolly fibre than is usual, and bear very large pods. Bates (*Text. Antiq.*) considers this plant to have been *Gossypium arboreum*, but that cotton was not cultivated in Egypt proper in ancient times. He states that the ancient Egyptian paintings and sculptures show no trace of cotton, while they depict flax cultivation and the purification of this fibre. Yates further asserts that cotton was first cultivated in Egypt in the thirteenth or fourteenth centuries. Prosper Alpinus (*De Pl. Aegypti*) supports this view, and significantly remarks that as late as 1592 the Egyptians imported cotton for their own use from Syria and Cyprus, and only cultivated the plant as an ornament or curiosity in their gardens. It is noteworthy that the early references to both Indian and Egyptian cotton indicate that a perennial plant was in use, and that the annual type was a later discovery, procured probably from Arabia, where it is stated to be indigenous.

Europe.—When the Saracens took Sicily in the ninth century, they proceeded at once to introduce cotton cultivation, and from the description given of the methods of cultivation in vogue it is quite apparent that an annual plant was used, probably that known to-day as *G. herbaceum*. In the following century they took the same plant across the Mediterranean into Spain, and it is recorded that during the three succeeding centuries Barcelona was the centre of a thriving cotton industry. Capmany writes in his history of the

commerce of Barcelona : "One of the most famous and useful of the industries of that city was the manufacture of cotton ; its workers were united in a guild in the thirteenth century, and the names of two of its streets have preserved the memory of the ancient locality of their shops".

Prior to the European conquests of the Saracens, cotton cultivation had been established in Crimea and southern Italy. The annual cotton plant was conveyed by the Saracens to Constantinople, Persia, and probably also to the Indian frontier, Egypt, and North Africa. Eventually cotton cultivation became widely spread in the countries on both shores of the Mediterranean, where a stabilised cotton industry flourished for several centuries.

The success of Vasco da Gama's voyage round the Cape of Good Hope, in 1498, opened up a direct route from Western Europe to India, and injuriously affected the commercial supremacy of Genoa and Venice. Still, as late as the sixteenth century, England depended upon the Levant for her supplies of cotton and cotton goods from India by the Mediterranean ports. It is recorded that in 1641 merchants bought cotton wool in London which came from Cyprus and Smyrna.

Africa.—The earliest record of cotton in Africa is given by the Moor, Leo Africanus, who was born in Spain in 1494, in his *Description of Africa*. Leo Africanus explored the basin of the Niger, where he found cotton growing, and the fibre being used for making cloth and sold to Barbary merchants in exchange for European cloth, brass vessels, and other commodities.

Japan.—According to Fesca (*Japanische Landwirtschaft*) cotton was first introduced to Japan, from India, in A.D. 781 ; but it was only cultivated for a brief period. It was reintroduced by the Portuguese at the end of the sixteenth century. It was not until the following century that systematic cultivation was begun.

The New World.—Cotton has been discovered in the ancient tombs of Peru. When Columbus visited the West Indies in 1492 he observed cotton growing in abundance, and this circumstance led him to believe that he had reached India. Both he and the early Spanish navigators saw quantities of it growing in the countries on the mainland of the New World, where its fibre was in common use for the

weaving of cloth, etc., from the West Indies to Peru, and from Mexico to Brazil.

Mexico.—Even before its conquest by Cortez, the annual production of cotton in Mexico has been estimated by Ruiz to exceed 116 million lb. In 1519 Cortez found cotton to be the principal article of clothing by the natives, and he utilised it for packing the clothes of his soldiers as a protection against the natives' arrows.

Brazil.—Although the earliest historians of Brazil make no mention of cotton cultivation, they maintain that the natives utilised the cotton of the indigenous plants in the manufacture of clothing and other articles. Magellan (1519) found the Brazilians using cotton for the manufacture of cloths and fishing lines. Cotton was certainly cultivated in Brazil as early as the sixteenth century, for G. S. de Souza (*Revista do Instituto do Brazil*, 1570-87) mentions that cotton plants were hoed two or three times a year in Bahia. The export of cotton from Brazil began about the middle of the seventeenth century.

United States of America.—It is a significant fact that, at the time of the settlement of America, cotton was known and was in common use practically everywhere between the parallels of 40° north and 40° south latitude, excepting in that enormous cotton-producing region which is now so familiarly known as the American Cotton Belt.

Whether cotton is indigenous to the United States is open to doubt, and the exact date of its introduction is unknown. It is recorded that De Vica discovered cotton growing wild in Louisiana and Texas in 1522, but little was known of the species of American cotton until two centuries later. Systematic cotton cultivation was not practised until 1621, and with seed introduced from the West Indies and the Levant. Nearly two hundred years elapsed before the industry became of any great importance. In 1784 a ship which had brought eight bags of cotton from America to Liverpool was seized because it was considered that this quantity of cotton could not have been produced in the United States. Donnell (*History of Cotton*) states that the first regular exportation of cotton from Charlestown, which consisted of one bag, arrived at Liverpool in 1785 and was consigned to John & Isaac Teasdale & Co.

Development due to Invention of Saw Gin.—The tedious operation of separating the seed from the lint by hand remained in vogue in the United States for many years. As early as 1472, Dubreuil, a French planter, had invented a machine for this purpose, but at this date there was little demand for a machine of this description and all records of it were lost. The ancient Indian “churka” roller gin was greatly improved by Dr. Joseph Eve in 1790. It was not until the saw gin came into use that the farmer was able to produce his crop at a profit. Eli Whitney claimed to have invented this machine. When he petitioned for a patent for it in 1793 his claim was disputed, and he conducted his defence for nearly a generation before obtaining a successful verdict. It is significant that during the year that Whitney’s gin was patented the United States production of cotton amounted to 6000 500-lb. bales; in 1795 he effected improvements in his gin and in the following year production amounted to 20,000 bales. Five years later the crop had increased to 96,000 bales, of which Great Britain took one-half.

Between 1830 and 1839 Indian tribes were removed from Georgia, Alabama, and Mississippi, which opened up large areas of new lands for cotton planting, and the year 1839 saw the largest crop yet produced, *i.e.* 1,580,959 bales.

World’s Cotton Crop at End of Eighteenth Century.—The world’s cotton crop in 1791 amounted to 980,000 bales of 500 lb. in weight; the production of various countries being as follows :

COUNTRY.	Cotton production (500-lb. bales).
India	260,000
Rest of Asia	380,000
Africa	92,000
Brazil	44,000
Rest of South America and Mexico	136,000
West Indies	24,000
United States of America	4,000
Other countries	40,000

Early Efforts to develop Indian Cotton Industry.—From 1829 to 1841 the East India Company made strenuous attempts to improve the standard of Indian cotton. American cotton growers were brought over in an effort to introduce the cultivation of New Orleans cotton, and large

sums of money were awarded in the form of prizes for cotton growing. Little success, however, attended this venture. Several years later considerable attention was again directed to the development of cotton growing in India. Proposals were made in England to raise £20,000,000 for expenditure in this connection, but the Mutiny caused the collapse of this scheme.

Great Britain's Cotton Imports.—At the end of the eighteenth century British imports of raw cotton from the United States amounted to over 20,000 bales, while those from India were less than 2000 bales. In 1801 Great Britain imported 13,000 bales from India, or less than one-third of that imported from the United States. Great Britain's total consumption of raw cotton at this period amounted to 108,000 bales. Great Britain's average annual imports of cotton during the period 1850–59 were $2\frac{1}{2}$ million bales, of which India contributed less than half a million bales annually. During the following decade, when the American cotton-growing industry was paralysed by the Civil War, Great Britain's average annual imports rose to $2\frac{3}{4}$ million bales, and India's contribution increased to $1\frac{1}{4}$ million bales. The manner in which India responded to the increased demand for cotton during the American cotton famine furnished a valuable example of her capabilities in this respect; for the requirements of her own mills, the first of which had been erected in 1818, at this time necessarily restricted the quantity available for export.

In 1899 India's cotton contribution to Great Britain fell to 77,000 bales. The United States had regained command of the market, and India had reverted to her position of a supplementary supplier. At this time there were in India 124 cotton mills operating over 21,600 looms and $2\frac{3}{4}$ million spindles, consuming 888,000 bales of cotton, and employing over 91,000 hands. India had ceased to export manufactured cotton goods, and now imported English cotton manufactures to the value of 20 million pounds sterling.

Development of the Cotton Manufacturing Industry.—In A.D. 800 cotton was in use for paper-making in Greece. Besides the countries already mentioned, cotton goods were manufactured as early as 1252 in Persia, 1368 in China, and 1497 in Spain and Italy. In 1530 Jurgen invented a cotton

spinning wheel at Brunswick. Cotton cloth was brought to England from Benin in West Africa in 1590.

Cotton was imported into England as early as 1298, but was at first used for candle and lamp wicks. England, and in all probability Europe as well, was first supplied with cotton from the Levant. Hakluyt, in his *Voyages, etc.* 1430, mentions the merchants of Genoa conveying cotton and other goods to England, and taking back woollen goods. In 1560 only small quantities of raw cotton were imported from the Levant, and these were spun into yarn by hand or by the distaff. In 1641 the principal part of the yarn in use was imported from the Levant, but as weft only, the warp being of linen. This procedure continued until 1772, when Arkwright and Strutt succeeded in making goods with a cotton warp. The industry, however, made little progress until 1782; during that year 33,225 bales of cotton were imported as against 14,603 in the preceding year.

Printing and dyeing cotton goods commenced in England in 1690. In 1770 an Act was promulgated forbidding the sale or use of foreign printed goods. Bleaching was generally introduced in 1763.

Early Manufacture of Flemish Fustians.—It is claimed that the Flemish were the first manufacturers of fustians. Capmany, the historian of Barcelona, however, states that the cotton industry of that city in the thirteenth century was known as “fustian manufactures”, “fustaneros” being weavers of cotton goods. The name fustian is derived from the word “fuste”, which denotes substance, and it was so named because it gave substance to the thinner cloth or silk garments in which it was used as a lining.

Origin of English Cotton Industry.—It is considered probable that the art of cotton manufacture was introduced into England from Flanders by the Flemish artisans, who ran away from their country in the sixteenth century. Cotton manufacturing appliances employed at this date were little superior to those that had been in use elsewhere for two thousand years. They consisted of the one-thread spinning wheel and the distaff. Except that the loom was more compact and solid, it was little better than the one that had been in use in India for centuries. It is therefore not surprising that the yarn lacked strength combined with firmness, and

in order to impart strength to the material it was necessary to make it heavy.

Baines' *History of the Cotton Manufacture* states that, commencing in 1760, Manchester merchants supplied weavers in neighbouring villages with linen yarn and raw cotton, and paid a fixed price for the completed web. The weavers were relieved of the difficulty of obtaining material and finding a market for their wares, and were thus able to pursue their work more expeditiously.

The growth of the English spinning industry was reflected in the decreased imports of yarn from India. In 1704 England took 114,100 lb. of yarn from India, but in 1760 only 2814 lb. Objections to the imports of Indian cotton goods had been raised in England for some time, and early in the eighteenth century Parliament enacted legislation to suppress their introduction. The import of Indian silks and printed calicoes was forbidden under a penalty of £200 for the buyer or the seller. The manufacture of calicoes, so named from their resemblance to the calicut manufactures of India, was first attempted in England in 1765.

Cotton Duties.—The amount of the duties imposed on cotton imported into England varied from time to time. Those in operation in 1798 were : from East India Company, 4 per cent *ad valorem* ; British Colonies, Turkey and United States, and elsewhere, 8s. 9d., 6s. 6d., and 1s. respectively per 100 lb. In 1833 cotton from British Possessions was taxed 4d. per cwt., and that from elsewhere 2s. 11d. per cwt. The cotton duties were repealed in 1845.

Regular Imports of American Cotton commenced.—Up to the latter part of the eighteenth century London imported more cotton than Liverpool. In 1789 London imported 48,000 bales as against Liverpool's 47,000, but Liverpool took the lead in the following year and, with the exception of the years 1793–94, she has retained it ever since.

In the year 1782 cotton began to be regularly imported into England from America, and a panic occurred in Manchester because more than 7000 bales arrived during the first four months of that year. The same year saw the first muslins manufactured in England.

Beginning of English Cotton Export.—It was about this date that England commenced to export cotton goods. As

a natural consequence, the demand for raw material increased, and manufacturers were threatened with a shortage of cotton yarn. The crude appliances employed by the spinners were already turning out their maximum capacity, and extra spinners were not available. Cotton yarn rose in price as the demand for it exceeded the supply, and the export trade was consequently restricted. Man's ingenuity was then applied to the improvement of cotton machinery. The early inventions were of course not faultless, still the principles on which they were constructed formed the basis upon which the intricate textile machinery of to-day has been elaborated.

Inventions of Cotton Machinery.—The men whose names are intimately associated with these early inventions and developments are as follows: Earnshaw invented the cotton reel in 1753, Highs the spinning jenny in 1763. In 1764 Hargreaves invented a machine to spin several threads at once. Arkwright's spinning machine was patented in 1769. In 1775 mule spinning was invented by Crompton. The "mule" was so called because it was a "cross" between Hargreaves' and Arkwright's patents. In 1785 Watt brought forward the first steam engine for cotton mills, and Cartwright first attempted the power loom.

Rapid Growth of English Cotton Industry.—The adoption of more efficient machinery, coupled with the introduction of the steam engine for motive power, rapidly converted a struggling industry into one of enormous dimensions. In 1832 the capital sunk in British cotton mills was estimated at £10,600,000. There were 143 cotton mills in England in 1787, but by 1835 they had increased to 1263; at the latter period they employed 100,886 males and 120,283 females. Still in 1837 there were more hand looms than power looms in operation, but twelve years later there were a quarter of a million power looms and only 60,000 hand looms.

Shortage of raw material next threatened to handicap the industry's further development. The supplies from the Levant, West Indies, and India were inadequate to meet the demands, and new cotton fields were eagerly sought for. Additional supplies were procured from Brazil before attention was directed to the United States. The origin, and quantity in lb., of cotton spun in Great Britain in 1831 were as follows: American, 205,435,480; Brazilian, 32,076,540; West Indian,

11,840,070 ; Egyptian, 7,383,860 ; East Indian, 3,101,400 ; total, 259,837,350. It is interesting to observe that, as early as 1844, the value of the exports of cotton manufactures and yarns was one-half of the total value of British exports. The official value of the exports of British cotton manufactures in 1800, 1810, and 1820 were £5,854,057, £18,951,994, and £22,531,079 respectively.

	1844.	1845.	1846.
	£	£	£
Total British exports . .	50,648,306	53,298,026	51,279,735
Cotton manufactures and cotton yarn exports .	25,805,338	26,119,331	25,600,693

IMPORTS OF RAW COTTON INTO THE UNITED KINGDOM
DURING THE YEAR 1924¹

	Quantity. Bales of 500 lb.	Value. £
From :		
Egypt	689,886	31,675,095
U.S.A.	1,893,851	67,155,776
Brazil	34,059	1,342,760
Other Foreign Countries . .	199,487	7,618,175
Total Foreign Countries . .	2,817,283	107,791,806
British Africa	118,927	4,804,849
British East Indies	200,694	6,169,337
British West Indies (including B.W.I. islands, Bahamas, British Guiana, British Hon- duras)	3,975	219,653
Other British Possessions . .	12,420	440,530
Total British Possessions . .	336,016	11,634,369
Total	3,153,299	119,426,175

DITTO, COTTON LINTERS

Bales of 500 lb.	£
13,293	169,344

DITTO, COTTON WASTE (UNMANUFACTURED)

Cwts.	£
437,618	1,939,673

¹ From *Accounts relating to Trade and Navigation of the United Kingdom*, Dec. 1924.

EXPORTS OF COTTON YARNS AND MANUFACTURES FROM THE
UNITED KINGDOM, 1924

Yarns.	Cotton Manufactures (except apparel).
£27,792,536	£171,504,485
Total, £199,297,021	

Development of American Cotton Manufacturing.—The first permanent American cotton factory was erected at Beverley, Massachusetts, in 1787, and others soon followed. Although carding and spinning were done by machinery, hand looms for weaving were in operation until a power loom was erected in 1815. For many years after the erection of cotton factories, hand looms and spinning wheels were in common use by women in their own homes. Owing to the blockade during the war of 1812, exports of raw cotton were checked, imports of cotton goods were reduced, and cheap raw cotton favoured the expansion of the manufacturing industry. At the termination of the war, prices rose in the United States and fell in England, and the American market was inundated with cheap English cotton goods, so that many of the American mills were compelled to close. This was merely a temporary check, for in 1832 the number of mills had increased to 800, with 33,000 looms and $1\frac{1}{4}$ million spindles, which employed 62,000 persons, and consumed 154,000 500-lb. bales of raw cotton. And within twenty-eight years the number of mills, looms, and spindles had increased to 1090, 126,000, and 5,236,000 respectively.

World's Cotton Spindles.—From 1876 to 1880 Great Britain's annual consumption of cotton exceeded that of the Continent by 454,720 bales, and that of the United States by 1,135,680 bales. From 1901 to 1904 the annual consumption of Great Britain was 1,796,480 bales and 660,800 bales less than that of the Continent and the United States respectively.

In 1914 the United Kingdom held $38\frac{1}{2}$ per cent of the spindles of the world, the United States 22 per cent, and Europe (including Russia) $30\frac{1}{2}$ per cent. Twenty years later British spindles have increased by 16,700,000, compared with an increase of 15,000,000 and 15,200,000 in the United States and Europe respectively. Before the Great War of 1914 the world's annual requirements of raw cotton amounted

to 25 million bales; Great Britain imported more than 4 million bales of an estimated value of £25,000,000, and exported cotton goods to the value of £125,000,000.

TOTAL ESTIMATED NUMBER OF THE WORLD'S COTTON SPINDLES
(000's omitted)

	1913.	1924.
Great Britain	55,653	56,750
France	7,400	9,359
Germany	11,186	9,464
Russia.	9,213	7,246
Italy	4,600	4,570
Czechoslovakia and Austria . .	4,865	4,511
Spain	2,000	1,813
Belgium	1,492	1,741
Switzerland	1,398	1,515
Poland	1,322	1,101
Netherlands	479	686
Sweden	534	568
Portugal	480	503
Finland	222	251
Other European Countries . .	165	1,180
United States of America . .	32,149	37,804
India	6,084	7,928
Japan	2,300	4,825
China	..	3,300
Brazil	1,200	1,700
Canada	855	1,167
Mexico	700	802
All other Countries	..	325
Total	144,297	159,109

The World's Cotton Crop.—During the twenty years 1905 to 1924 the world's total average production of cotton is estimated at 21,810,000 500-lb. bales; in this period the biggest crop, 27,875,000 bales, was recorded in 1914-15, and the smallest crop, 16,914,000 bales, was recorded in 1921-22. Estimating the average value of cotton to-day at 1s. per lb., it will be seen that the total value of the world's cotton crop is £545,250,000, and is thus the most important commodity of international commerce.

The enormous amount of labour involved in producing this valuable crop is shown by the fact that, as 3 lb. of seed cotton yield about 1 lb. of lint, and as workers pick on an average some 100 lb. of seed cotton per day, it follows that

327 million days' work are employed in harvesting the crop; while as the average yield of lint is less than 100 lb. per acre, the total area cultivated with cotton is more than 109 million acres.

The rate at which the world's cotton spindleage has increased has already been shown. America produces more than 50 per cent of the world's cotton crop. During the period 1900-1905 America exported 64 per cent of its cotton crop and consumed 36 per cent; the figures are now reversed, for it exports 35 per cent and consumes 65 per cent.

With the resumption of normal trade conditions in Europe and elsewhere the reduction of American supplies must be severely felt unless there is a very considerable increase in the supplies from other centres, and this circumstance is reflected in the price of cotton, as shown below :

Cotton Prices :

AVERAGE PRICE OF "MIDDLING" AMERICAN COTTON IN LIVERPOOL

Period.	Pence per lb.
1899-1900 to 1903-4	5.44
1904-5 to 1908-9	5.79
1909-10 to 1913-14	7.16
1914-15 to 1918-19	13.29
1919-20 to 1923-24	16.23

As regards record prices, it is interesting to note that, in 1786, and as a result of the American war, "very fine Bourbon" sold at 7s. 6d. to 10s. per lb. In the years 1799 and 1809 Sea Island cotton fetched over 5s. per lb., while in 1814 it went to 6s. per lb. During the cotton famine of the 'sixties Egyptian cotton fetched 31½d. per lb. and American cotton 31¾d. per lb. In February 1920 Middling American fetched as much as 31.16d. per lb. and F.G.F. Sakellaridis 8s. 3d. per lb.

About 1845 the price of American cotton fell to 3¼d. per lb. and Indian to 2d. per lb. In 1894 and again in 1898 the price of American Middling fell below 3d. per lb.

The World's Consumption of Cotton.—The table given overleaf, showing the world's consumption of cotton, has been prepared from statistics compiled by Prof. J. A. Todd from various sources.

Season.	Running Bales (000's omitted).	Season.	Running Bales (000's omitted).
1884-85	7,444	1903-4	14,010
1885-86	8,120	1904-5	18,326
1886-87	8,505	1905-6	18,589
1887-88	8,891	1906-7	20,058
1888-89	9,267	1907-8	20,019
1889-90	9,795	1908-9	20,873
1890-91	10,511	1909-10	20,391
1891-92	10,565	1910-11	22,771
1892-93	10,291	1911-12	24,034
1893-94	10,580	1912-13	22,628
1894-95	11,543	1913-14	25,396
1895-96	11,605	1914-18	No returns
1896-97	11,880	1919-20	19,453
1897-98	12,888	1920-21	18,462
1898-99	14,015	1921-22	21,748
1899-1900	13,773	1922-23	22,689
1900-1	13,416	1923-24	20,933
1901-2	14,415	1924-25	23,833
1902-3	14,437		

The World's Chief Centres of Production and Consumption.

—The tables given below, showing the world's chief centres of cotton production and consumption, are also prepared from statistics compiled by Prof. J. A. Todd.

CHIEF CENTRES OF COTTON PRODUCTION

(Bales of approximately 500-lb. Linters included in American Crop ;
000's omitted)

	America.	India.	Egypt.	Russia.	China.	Others.	Total.
1902-3	10,784	3,367	1,168	342	1,200	801	17,662
1903-4	10,016	3,161	1,302	477	1,200	751	16,907
1904-5	13,697	3,791	1,263	536	756	803	20,846
1905-6	10,726	3,416	1,192	604	788	938	17,664
1906-7	13,305	4,934	1,390	759	806	1,027	22,221
1907-8	11,326	3,122	1,447	664	875	950	18,384
1908-9	13,432	3,692	1,150	698	1,933	971	21,876
1909-10	10,386	4,718	1,000	685	2,531	950	20,270
1910-11	11,966	3,889	1,515	895	3,467	968	22,700
1911-12	16,109	3,262	1,485	875	3,437	1,058	26,226
1912-13	14,091	4,421	1,507	870	2,360	1,160	24,409
1913-14	14,614	5,066	1,537	969	1,963	1,239	25,388
1914-15	16,738	5,209	1,298	1,152	2,332	1,146	27,875
1915-16	12,013	3,738	961	1,413	2,068	990	21,083
1916-17	12,664	4,489	1,022	1,085	1,569	1,039	21,868
1917-18	12,345	4,000	1,262	605	1,583	1,106	20,901
1918-19	12,817	3,972	964	334	1,725	1,312	21,124
1919-20	11,921	5,796	1,114	302	1,690	1,535	22,358
1920-21	13,711	3,600	1,206	120	1,351	1,462	21,440
1921-22	8,378	4,479	972	78	1,340	1,767	16,914
1922-23	10,438	5,196	1,243	137	1,955	1,799	20,764
1923-24	10,811	5,162	1,306	295	1,785	1,871	21,230
1924-25	14,497	6,141	1,455	450	1,976	2,325	26,844
*1925-26	16,900	5,569	1,600	927	2,068	2,500	29,564

* Estimated.

CHIEF CENTRES OF COTTON CONSUMPTION
(Running Bales; 000's omitted)

	United Kingdom.	Continent.	United States of America.	Asia.	All others.
1912-13	4,274	7,914	5,719	3,765	956
1914-18			no returns		
1919-20	3,620	3,271	6,733	5,006	823
1920-21	2,024	4,747	5,376	5,436	879
1921-22	2,865	5,341	6,528	6,081	933
1922-23	2,770	5,158	7,253	6,437	1,062
1923-24	2,718	5,329	6,144	5,973	771

WORLD'S PRODUCTION OF COTTON
(500-lb. bales; 000's omitted)

Compiled by United States Department of Commerce

Season ended August 31.	United States Production.	All others.	Total World Production.
1908-9	13,242	7,362	20,604
1909-10	10,005	6,983	16,988
1910-11	11,608	7,248	18,856
1911-12	15,692	6,555	22,247
1912-13	13,703	7,847	21,550
1913-14	14,156	8,456	22,621
1914-15	16,135	8,726	24,861
1915-16	11,192	7,269	18,461
1916-17	11,499	7,425	18,924
1917-18	11,302	6,839	18,141
1918-19	12,041	6,724	18,765
1919-20	11,421	8,798	20,219
1920-21	13,440	6,235	19,675
1921-22	7,954	6,730	14,684
1922-23	9,762	7,885	17,647
1923-24	10,140	9,160	19,300
1924-25	13,300	10,000	23,300
*1925-26	15,602	10,010	25,612

* Estimated.

CHAPTER II

BOTANICAL

Characters of the genus *Gossypium*—Origin of cultivated cottons difficult of determination—Linnæus's classification—Great value of Watt's classification. Section I.: Uncultivated fuzzy-seeded species. Section II.: The Asiatic group. Section III.: The American group. Section IV.: Naked-seeded cottons. Section V.: Uncultivated naked-seeded species. Seed characters—Glands—Varieties—Upland cotton—*G. hirsutum* introduced to America from Chelsea Physic Garden—*G. mexicanum* and *G. vitifolium* introduced from Mexico—Long staple Uplands—*G. hirsutum* most successful American cotton in India—Development of the fibre—Composition of lint—Length of lint.

THE cotton plant belongs to the natural order Malvaceæ, the mallow family, to which also belong such well-known plants as Hibiscus, Lavatera, and the Hollyhock. Scientifically it is known by the generic name *Gossypium*, derived from "Gossypion"; this being the name by which, according to Pliny, cotton was known in the Island of Tylos.

The species are extensively distributed in both hemispheres, and on both sides of the equator from 45° north latitude to 34° south latitude. Although different kinds of cotton are distinguished as annuals or perennials, all cottons are perennial if grown under suitable conditions, and eventually develop into bushes or even small trees. It is only for convenience that cotton is cultivated as an annual.

Characters of the Genus Gossypium.—The chief diagnostic characters that are generally accepted as denoting *Gossypium* are included in the following description of the genus: Tall herbs or sub-arboreous shrubs; usually hairy, with long or branched hairs or soft and tomentose, or the pubescence may be short and stellate. With the exception of the root, all parts, even sometimes the cotyledons, interspersed with small black dots or glands. Roots long, branched, and deeply penetrating. Stem erect, terete, branching, and widely

spreading. Branches round or angular, erect or spreading. Leaves alternate, petiolate, cordate or sub-cordate, lobes 3 to 7 or occasionally 9, the lower and upper ones sometimes entire. Venation 3-7 veined, branching and net-like, the centre and adjacent veins having a gland one-third of their length distant from bases. Stipules in pairs, linear-lanceolate, acuminate, sometimes caducous.

Flowers rather large, yellow or purple, pedunculate. Peduncles angular, frequently thickened at the ends, short, erect or spreading, sometimes pendulous in fruit, with leafy involucre. Involucre 3 or 4 leaved, bracteoles large, cordate, erect, sometimes united at base or adnate to calyx, incised, dentate or entire, occasionally linear. Calyx short, truncate, 5-dentate. Corolla hypogynous. Petals 5, sometimes coalescent at base, and by their claws adnate to lower part of stamen tube, obovate, transversely dilated at summit, in bud convolute. Staminal column dilated at base surrounding the ovary, bearing indefinite, threadlike filaments, naked below, above narrow and carrying the anthers. Anthers kidney shaped, one-celled, dehiscing by semicircular opening into two valves. Ovary 5-locular, sessile; loculi with ovules sparse or indefinite. Style clavate at the apex, with 5 furrows and 5 stigmas.

Capsule leathery, mucronate, oval, ovate-acuminate, or sub-globose; dehiscence locucidal by 3 to 5 valves. Seeds sub-globose, oblong or angular, fibrous or more rarely almost glabrous. Fibre frequently of two kinds, one short and felt-like and closely attached to the seed, the other long and twisted, of single cells, more readily detached from the seed; albumen thin, membranous or absent. Cotyledons strongly folded, auriculate at base, enclosing the upright radicle.

Origin of Cultivated Cottons difficult of Determination.—It is a striking anomaly that, although cotton has been cultivated from prehistoric times, the study of such an important genus was for long neglected by botanists. As cotton seed has been constantly exchanged between various countries for several centuries, and the plant exhibits a remarkable tendency to hybridise, and to respond rapidly to improved conditions as regards cultivation, soil, and climate, it is not surprising that difficulty has been experienced in establishing the origin of different cultivated cottons, for some of those in

most general cultivation are totally unknown in the wild state. As a consequence the origin of some of the chief cultivated stocks can only be conjectured.

Linnaeus's Classification.—Linnaeus named the first species from cultivated plants, and classification proceeded on the basis of his 5 or 6 types only, on the assumption that no other species existed. Later, some botanists proposed the reduction of all types to one species, others proposed their reduction into three divisions, *i.e.* black-seeded, white-seeded, and khaki-seeded cottons, while others have unnecessarily increased the number of species by making separate species of cultivated forms. Toderæ was of opinion that there are as many as 54 species, while Parlatore considered 7 sufficient. Aliotta and Wildemann made 5 species, but with numerous varieties and cultivated races or hybrids under each. Buchanan-Hamilton suggested 2 or perhaps 3 species. It is thus conceivable that considerable confusion and ambiguity was caused.

Great Value of Watt's Classification.—Eventually order was brought out of chaos by Sir George Watt's monumental work, *The Wild and Cultivated Cotton Plants of the World*, to which I am indebted for much of the information on this subject that is given in the following pages. As regards diagnostic characters, he states: "The most instructive characteristics are derived from the position and condition of the bracteoles, the presence or absence of nectar-yielding glands; and the nature of the floss and fuzz that surround the seed. By a study of these aspects, the species may be referred to five sections that seem almost sub-generic in value, since the species thus brought together are evidently closely related both structurally and geographically."

SECTION I. UNCULTIVATED FUZZY-SEEDED SPECIES :

(9 species.) Seeds with a fuzz but no floss. Perennial shrubs not cultivated; species distributed from the western coast tract and islands of America to Australia. *G. Sturtii*, F. v. M.; *G. Davidsonii*, Kellogg; *G. klotzschianum*, Andss.; *G. Robinsoni*, F. v. M.; *G. Darwinii*, Watt; *G. tomentosum*, Nutt.; *G. drynariodes*, Seem.; *G. Harknessii*, Brandg.; and *G. Stocksii*, M. Mast.

SECTION II. THE ASIATIC GROUP :

(4 species and 12 varieties.) The Asiatic group of fuzzy-seeded cottons with united bracteoles. Perennial or annual shrubs, met with on the shores of the Mediterranean, through Africa, Egypt, Arabia, Asia Minor, Kurdistan, Persia, India, China, Japan, and the Malay Peninsula and Archipelago.

G. arboreum, Linn., the tree cotton of India and Africa, and its 4 varieties: *sanguinea*, the red-flowered arboreum cotton; *neglecta*, Bengal cotton; *assamica*, Garo Hill cotton; and *rosea*, Varadi cotton.

G. Nanking, Meyen, Chinese, Siam, or Nanking cotton, and its 6 varieties: *himalayana*, Bagar or Watni cotton; *rubicunda*, red-flowered Nanking cotton; *nadam*, Coconada and Wa-gale cotton; *bani*, Berar, Oomra, Hinganghat, and Nagpur cotton; *roji*, Gujaret tree cotton; and *soudanensis*, Sudan cotton.

G. obtusifolium, Roxb., Indian wild cotton, and its 2 varieties: *wightiana*, Kahnami, Goghari, Dhollera, Kumpta, Uppam, Kanvi, Wagria, and Tellapatti cotton; and *africana*, African herbaceous cotton.

G. herbaceum, Linn., Levant cotton. This is the species that was first cultivated in Europe, and is the best known representative of the Asiatic cottons.

SECTION III. THE AMERICAN GROUP :

(10 species and 1 variety.) The American group of fuzzy-seeded cottons with free bracteoles. A fair percentage exist as wild forms; the green-seeded cotton, which is the chief cultivated species, is closely associated with British colonists. None are Asiatic, and with one exception all are American.

G. mustelinum, Miers M.S. in B.M., wild perennial Brazilian cotton with rufous fuzz and lint.

G. punctatum, Sch. et Thon., probably the origin of *G. hirsutum*, or many of the short staple cottons of the United States. There are two forms of this plant: (i.) *var. nigerica*, African wild cotton; and (ii.) *var. jamaica*, American and West Indian moqui cotton.

G. hirsutum, Linn., New Orleans and Georgia short staple American cotton, i.e. virtually a cultivated state of

G. punctatum. *G. h. var. religiosa*, Watt, the Sacred, Khaki, Roman, or Siamese cotton, possibly a cultivated form of *G. prostratum*, Sch. et Thon., with rusty fuzz and lint.

G. Palmerii, Watt, a wild species of Mexico, which produces a small fruit with a low yield of lint, and thus is unlikely to be cultivated.

G. fruticosum, Tod., Mexican cotton.

G. Schottii, Watt, Yucatan, Mexico wild cotton, producing rufous fuzz and lint, the latter so inferior in quality and quantity as not to justify cultivation.

G. lanceolatum, Tod., Mexico.

G. microcarpum, Tod., Red Peruvian cotton, with greenish or rufous fuzz, dirty white, coarse lint, and seeds partly adhering.

G. peruvianum, Cav., possibly the origin of many Egyptian cotton races or hybrids, such as Ashmouni, Afifi, Zafiri, and Abassi. It produces grey, green, or rust-coloured fuzz and copious, sometimes silky, lint. Watt suggests the possibility of this not being a true botanical species, but that it may have originated from the crossing of other fuzzy-seeded cottons of Central or South America, such as *G. punctatum* with *G. barbadense* or *G. vitifolium* and in some cases *G. brasiliense*.

G. mexicanum, Tod., Mexican and the bulk of Upland American cottons. The fuzz is ash coloured, and the lint dull white to reddish. This is now probably the most important of all stocks. As there is no record of its having been collected in a wild state, it is probably of comparatively recent origin, and a hybrid derived from say *G. punctatum* or *G. hirsutum* as one ancestor, crossed with *G. purpurascens* on the one hand or *G. vitifolium* or *G. barbadense* on the other. Where the *hirsutum* element predominates the plants are pilose, and where *purpurascens* they are glabrescent.

SECTION IV. NAKED-SEEDED COTTONS :

(5 species and 1 variety.) Naked-seeded cottons with lint readily separable from the seeds ; bracteoles free or nearly so, and glands conspicuous. Both Old and New World forms are found in this section, but only one, *G. Taitense*, has been met with in a wild state. It is to be observed that no Asiatic indigenous cotton has naked seed ; such cottons emanate from

three great centres situated between 15° north and 20° south latitude, *i.e.* Polynesian Islands, East Africa, and South America.

G. Taitense, Parl., Polynesian wild and cultivated cotton.

G. purpurascens, Poir, Bourbon, Porto Rico, or Siam cotton ; its first mentioned designation is due to the circumstance that French colonists carried it throughout the world. This is probably the cultivated form of *G. Taitense*, and it is essentially an insular plant.

G. vitifolium, Lamk., the vine-leaved perennial cotton. This is one of the chief ancestors of some of the finest commercial cottons of the world ; it is the stock of some of the best quality Egyptian long staples, Sea Islands, and higher grade South Americans. It is probably the earliest known stock of *G. barbadense*. In cultivation it rarely exists pure, but through hybridisation merges into *G. peruvianum*. Its origin is considered to be Central and South America and Lesser Antilles.

G. barbadense, Linn., Antilles cotton. Found only cultivated and usually as an annual. It is separated from *G. vitifolium* more from industrial rather than botanical considerations. It embraces forms of Sea Island cotton and many long staple cottons of the United States and Egypt. Its habitat is Antilles, Central and South America. *G. b. var. maritima*, Watt, Sea Island, Gallini, and Jannovitch cottons of Egypt. Sea Island cotton is probably not indigenous to the West Indies ; yet it would appear that the United States obtained their stock of Sea Island cotton through the West Indies, sometime between the middle and the end of the eighteenth century. Sea Island cotton may have been developed by cultivation in the West Indies ; it is well recognised that West Indian planters devoted considerable attention to improving the quality and yield of cotton, until their interest in cotton lapsed for sugar cultivation. After its introduction to the United States, Sea Island cotton was considerably altered in habit by cultivation, and in one important respect by the shortness of the summers and selection from a perennial to an annual habit. It would thus appear that Sea Island cotton is a comparatively recent development, both in the West Indies and in the American Sea Islands, from culturally improved hybrids, possibly

natural, of *G. vitifolium* or *G. barbadense* with *G. brasiliense*. The so-called Sea Island cottons of Hawaii, Fiji, and Queensland are probably special races of *G. barbadense* or *G. vitifolium*.

G. brasiliense, Macf., Kidney or Pernambuco cotton, is indigenous to South America. The seeds are joined together in a kidney-shaped mass in each of the three cells of the capsule. This union of the seeds may be regarded as a special protective adaptation against weevil attack. This cotton was recorded shortly after the discovery of Brazil, and attracted attention in Europe next to Levant cotton, *G. herbaceum*. In the last century it was a far more important species than it is to-day, for it is probably now the least favoured of all the cultivated stocks, although it is more widely distributed than any other cultivated cotton.

SECTION V. UNCULTIVATED NAKED-SEEDED SPECIES :

This section contains only one species, *G. Kirkii*, M. Mast., from East and Central Africa. Naked-seeded cotton with bracteoles quite free and floral glands absent. The lint is short, woolly, and rust coloured ; the plant is not cultivated.

Seed Characters.—It should be observed with regard to the seeds of wild cottons that they may have : (i.) fuzz¹ only ; at least nine species can be placed in this category, and none are found in cultivation ; (ii.) fuzz and lint¹ ; and (iii.) lint only. The fuzz, and often the lint as well, is khaki or rust coloured. Apparently the mixture of fuzzy seed (ii.) and naked seed (iii.) does not occur in the wild state, so it would appear that hybridisation only may be responsible for it under cultivation. In this connection it is significant that wild naked-seeded and fuzzy-seeded cottons rarely occur in a wild state in the same country. But it is not uncommon in cultivation for the progeny of a naked-seeded cotton to become fuzzy-seeded and vice versa.

The white woolly fuzz or white lint are due to cultivation, and the appearance of red or khaki colouring is an indication

¹ The seeds of cultivated fuzzy-seeded cottons have two kinds of fibre : (a) the "lint", which is the cotton of commerce, that is removed in the process known as ginning ; and (b) the "fuzz", which is very short and adheres closely to the seed, and is not removed by ordinary ginning processes.

of reversion to the ancestral type. In group (ii.) the lint is not readily separable from the seed, and hence the cultivated forms from these require saw gins to remove the lint ; whereas in group (iii.) the lint is readily separable from the seed, and consequently the cultivated forms are dealt with by roller gins. The matter of ginning will be more fully discussed in a later chapter.

The wild species *G. Kirkii*, which is never cultivated, appears to be the only cotton with purely naked seed ; even Sea Island cotton has almost invariably a minute tuft of fuzz surrounding the beak of the seed.

Glands.—The glands of the cotton plant are of three kinds, which probably function as stores of food material to be used by the plant in case of necessity, while those which discharge nectar or aromatic substances serve to attract insects to the plant for pollination purposes : (1) What are described as minute glandular dots, more or less embedded in the cortex of the foliar and floral leaves as well as in the capsule and seed. These dots are round and filled with a violet colouring matter which is soluble in alcohol. These are almost universally present. Those that are exposed to light are surrounded by an envelope of flattened cells that bear anthocyan, while the glands contain quercetin, probably wholly or partly in the form of its glucosids, ethereal oil, resins, and possibly tannins. The flattened cells that surround glands that are not normally exposed to light contain no anthocyan but gossypol. (2) Oblong or circular glands, visible on the under surface of the veins of the leaves. There may be one gland on the mid-rib only, or three or more, or they may be absent altogether. They discharge nectar, which is eagerly devoured by various insects. (3) Extra floral glands ; these also secrete a sweet fluid. They are rounded, of a bright yellow or red colour, and are found, three in number, on the apex of the peduncle, and the same number on the base of the calyx tube.

Varieties.—The botanical varieties recognised by Watt are marked and permanent types, which must not be confused with the numerous forms that are known as varieties by cotton growers. Modern varieties are mostly highly cultivated forms of cotton, and not distinct species. The primary factor in bringing about this variability is obscure, but it is

most probable that hybridisation is important. The plant sports readily, and responds quickly to change of environment, so that under new conditions its form and habit may be greatly modified in a few seasons. These circumstances have been taken advantage of in the introduction of "new" varieties, and unfortunately with new names.

Upland Cotton.—The best "Uplands" are often cultivated states of *G. mexicanum* rather than of *G. hirsutum*. Both forms, however, are apparent as well as others. Upland varieties of *G. herbaceum* have been so much hybridised with *G. hirsutum* that they have been frequently accepted as grades of the latter. Watt considers that an extreme view is taken by American botanists in the statement that "the Upland type of cotton was recognised as a distinct species by Linnæus under the name *G. hirsutum*, but many subsequent writers have erroneously confused the Old World species *G. herbaceum*, which is not cultivated in the United States, though often reported so". He points out that *G. herbaceum* was largely cultivated in the United States prior to 1732, and for many years after was the Upland cotton of that country, and it still survives, but mostly in a state of hybridisation with *G. hirsutum*.

G. hirsutum introduced to America from Chelsea Physic Garden.—Seeds of *G. hirsutum* grown in the Chelsea Physic Garden in 1732 were sent out to the United States, and the plant eventually became distributed throughout the cotton-growing States. It became known as the green-seeded cotton, and was considered "vastly superior" to Levantine cotton, *G. herbaceum*, and by 1786 it was the plant most commonly grown in America. It is one of the kinds that has changed most rapidly under cultivation. In the higher lands and cooler regions of the north, *G. hirsutum* was used for improving the stock of *G. herbaceum*. These cottons were given the name Upland to distinguish them from those referred to in the next paragraph.

G. mexicanum and G. vitifolium introduced from Mexico.—Early in the nineteenth century, *G. mexicanum* and *G. vitifolium* were introduced from Mexico to Mississippi, and these species were largely used with advantage in the warmer regions to cross with *G. hirsutum*. The gradual loss of the hirsute character, which became so noticeable in course of

time, indicates the influence of the *G. mexicanum* strain, but of a large number of specimens of American cottons that Watt received from the United States Department of Agriculture, he placed 7 with a strong strain of *G. hirsutum*, 40 even more nearly *G. mexicanum*, and the balance forms of *G. punctatum*, *G. barbadense*, etc. A large number of modern Uplands have been produced by crossing *G. hirsutum* with some Mexican plant; according to Watt "the bulk of the American cotton stock of present-day cultivation might be described, and accurately so, as consisting of forms of *G. mexicanum*".

Long Staple Uplands.—Long staple Uplands appear to be hybrids of *G. hirsutum* $\times$ *G. barbadense*, with little or no trace of *G. mexicanum*.

The habit of the "cluster cottons", which are found both among Uplands and Sea Islands, is due to the suppression of the lateral shoots, which brings three or four flowers into an axillary cluster.

It is to be observed that all American and African varieties with fuzzy seeds have pilose leaves, whereas those with naked seeds have sub-glabrous leaves.

Watt places some well-known American varieties as follows: Durango = *mexicanum* $\times$ *hirsutum*; Molango = hybrid of *hirsutum* approximating closely to *punctatum*; Allen = hybrid mainly *hirsutum*; Peeler = *hirsutum* hybrid; Simms = *hirsutum* $\times$ *mexicanum*; Sunflower = *hirsutum*; Russell Big Boll = *hirsutum* $\times$ *mexicanum*; Culpepper = *mexicanum* $\times$ *hirsutum*; Triumph = *mexicanum* $\times$ *hirsutum*.

G. hirsutum most Successful American Cotton in India.—In India *G. hirsutum* is the most successfully acclimatised of all the American cottons, and has there almost reverted to the specific type *G. punctatum* var. *nigerica*. This is an indication that, when neglectfully or defectively cultivated, *G. hirsutum* reverts to *G. punctatum* var. *nigerica*, just as, conversely, *G. punctatum* var. *nigerica* passes to *G. hirsutum*.

Development of the Fibre.—Each lint fibre or hair is formed by the development of a single epidermal cell of the outer coat of the ovule. This development commences as soon as the flower opens, and proceeds quite independently of pollination. The number of cells of an individual ovule that behave in this manner is primarily determined by its inherited

constitution, although the plant's environment during the period of fibre development is probably a contributory factor. The total number of fibres or hairs produced on a cotton seed is approximately 10,000. The wall of the fibre remains very thin until the fibre has attained its full length ; then material is laid down on the inner wall, increasing its thickness and strengthening it. The thickening process proceeds slowly each day, and continues during the developing period of the fruit or boll. This daily deposition of thickening layers is in the form of rings, each ring representing one day's growth, and is analogous to the growth of a tree trunk in annual layers. It is probable that many of the valuable commercial properties of cotton are dependent on the concentric tubular structure thus formed.

The growth in length of the fuzz fibres is checked, but their growth in thickness is almost unrestricted, and is completed in a few days. As a consequence, the growth rings of the fuzz fibre are much coarser than those of the lint fibre.

During the period of growth, the lint fibre is cylindrical in shape with a cavity that is continuous from end to end of the cell. When it reaches maturity, it loses its moisture, the cell collapses, and a flat, ribbon-like structure is formed, which is spiral or twisted, and the two edges of the cell present a thickened appearance. The twist does not take the form of a complete revolution in one direction, but sometimes in one direction and sometimes in the other. The twist is not uniform in all kinds of cotton, for some have much fewer spiral twists than others. The natural twist of cotton is of immense economic importance, for it facilitates the operation of spinning the fibre into yarn or thread. This characteristic likewise readily distinguishes cotton from silk-cottons or flosses, whose fibres have no twist.

Numerous minute pores are present on the walls of the fibre ; these and its canal-like structure provide relatively large air spaces, and this spongy character supplies a considerable surface on which water and dyes can be absorbed.

Composition of Lint.—Cotton lint is composed of 90 per cent of cellulose, 7·8 per cent of water, 0·4 per cent of wax and oil, 0·6 per cent of nitrogenous matter, and 1 per cent of mineral matter. The wax occurs as a thin layer on the surface.

Length of Lint. Lint varies in length, in different kinds of cotton, from a fraction of an inch to over 2 inches: *e.g.* Indian and Chinese, $\frac{3}{4}$ "-1"; Asia Minor, $\frac{3}{4}$ "-1 $\frac{1}{8}$ "; Brazilian, $\frac{3}{4}$ "-1 $\frac{1}{4}$ "; Russian, $\frac{9}{16}$ "-1 $\frac{1}{8}$ "; West African, American Upland, 1"-1 $\frac{1}{8}$ "; East African, 1"-1 $\frac{1}{4}$ "; Peruvian, 1"-1 $\frac{1}{2}$ "; Long Staple American Upland, 1 $\frac{1}{2}$ "; Egyptian, 1 $\frac{1}{4}$ "-1 $\frac{3}{4}$ "; Florida and Georgia, Sea Island, 1 $\frac{1}{2}$ "-1 $\frac{3}{4}$ "; Carolina "Islands" and West Indian, Sea Islands, 2" and over.

The diameter of various commercial cotton fibres is approximately as follows: Sea Island, 0.00064 in.; Upland, 0.00077 in.; "Rough" Peruvian, 0.00078 in.; Brazilian, 0.0008 in.; Indian, 0.00084 in.

CHAPTER III

COTTON PRODUCTION IN THE UNITED STATES

Cotton the most important crop—Development of the industry—Subsidiary crops—Methods of farm management—Croppers—Wage hands—Tenant farms—The cotton grower's finances—Climate and soil—Size of farms—Average size of crops—Principal types of cotton—Improved cultural methods—Divergent cultural methods—Areas planted with cotton in different States—Land drainage—Land preparation for planting—Cultivation—Fertiliser application—Seed planting—Thinning or chopping out seedlings—Eastern cultural methods—Western cultural methods—The yield of cotton—Picking—Crop forecasts—Handling the crop—Bolly and snap cotton—Linters—Cotton seed—Warehousing—The United States official cotton standards for grade—Crop deterioration—Cotton markets—Cost of production—Cotton production in various States—The Sea Island cotton industry—The industry's development—The industry's decay—Handling the crop—The cultivation of Sea Island cotton—Cotton production under irrigation—Irrigated cotton cultivation—Supply and distribution of American cotton.

Cotton the most Important Crop. — Cotton is the most important commercial crop of the United States. Although the total value of the maize crop exceeds that of cotton, the latter is of more commercial importance, for the greater part of the maize crop is consumed on the farms where it is grown, whereas most of the seed and all the lint of the cotton crop are sold. American cotton mills consume more than one-half the lint produced in the country, and the value of the exported balance is in excess of that of the exports of any other crop.

Within the cotton belt, the value of the cotton crop exceeds that of all the other crops combined. The cotton belt is the area of specialised cotton production in the southern portion of the United States, which extends from the Atlantic coast through North and South Carolina, Georgia, Florida, Alabama, Mississippi, Arkansas, Western Tennessee, and Northern Louisiana, and into Texas and Oklahoma. In the southern States it is the main and often

virtually the sole source of income of most of the farmers. The economic life of these States is thus seriously affected by low cotton prices, or any other factor which depreciates the profits from this crop.

There are approximately 2 million growers, 23,000 ginneries, 900 cotton-seed oil mills, 3000 public storage places, and 2100 cotton-consuming establishments. In addition there are numerous transport companies, local buyers, merchants, and others who handle cotton during the season.

For many years the United States has produced the greatest quantity of cotton, its nearest competitors being India, China, Egypt, and Brazil. All available areas in the United States have now been tested for cotton production, and the area of production has spread across the cotton belt from east to west.

Development of the Industry.—In 1840 the area under cotton was only one half as large as that to-day. During the following decade, the planting of vast areas of new land, admirably adapted to cotton cultivation, resulted in a serious fall in prices; nevertheless, production increased by 50 per cent. Prices improved in the following decade, and increased production continued, more especially in the south-western States.

The increased transport facilities afforded by the construction of railways, in the period 1850–1870, from the coast to North and South Carolina, Georgia, and Alabama greatly encouraged the development of cotton production in these States.

In the south the cotton industry received a severe temporary check during the Civil War. In 1866 the crop was less than 2 million 500-lb. bales, which was little more than that of 1839.

In 1879 all the states, with the exception of Alabama and Louisiana, produced record crops. The total crop for that year, 6 million bales, exceeded all previous records.

Within another twenty years the crop was doubled. This increase was largely due to railway expansion in Texas, followed by the substitution of cotton for grazing and grain farming in the Black Waxy Prairie country, extension of cotton planting in Arkansas and Oklahoma, and improved cultural methods combined with the more extensive application of fertilisers to the light, sandy soils in the east.

During the last-mentioned period, development was specially noticeable in Oklahoma and Western Texas. Cotton cultivation was introduced to the irrigated areas of Southern California and Arizona, cotton seed increased in value, cotton manufacturing in the south made rapid progress; it was also an era of increased foreign competition, while the spread of the boll weevil, which first entered Texas from Mexico, began to cause serious alarm.

The acreage under cotton cultivation continued to increase until 1914. That year saw the zenith of United States cotton production; the crop amounted to 16 million bales, so that production was quadrupled in little more than half a century.

The ravages of the boll weevil since 1914 have greatly reduced production. The 1921 crop was the smallest that had been produced for twenty-six years.

The average area devoted to cotton production in the United States is about 35 million acres, or nearly 12 per cent of the total area of the cotton belt, which is 300 million acres. The actual area planted with cotton was in 1920-21, 37,043,000 acres; in 1921-22, 31,678,000 acres; in 1922-23, 34,016,000 acres; in 1923-24, 38,709,000 acres; in 1924-25, 40,115,000 acres; while that for 1925-26 is estimated at 42,120,000 acres. To plant this area, 500,000 tons of seed are required, or about one-tenth of the total annual production of seed.

Subsidiary Crops.—In the central portion of the cotton belt, about one-half of the land is devoted to cotton cultivation. A great diversity of crops is produced for home consumption, for the distribution of the labour for the cotton crop enables this to be done without reducing the cotton acreage. Maize is the most important of these crops, and in some regions equal acreages are under cotton and maize.

In the south, considerable quantities of wheat, oats, rye, sweet and Irish potatoes, cow peas, sorghum, and garden vegetables are produced. Still many farmers do not grow sufficient produce to supply the needs of their own homes and to feed their livestock. Consequently a large amount of foodstuffs and grain is annually imported from the north.

In the south the soils are better adapted for cotton cultivation than for other staple crops; there is a denser agricultural population, and cheaper labour than in other parts of the United States. These are important factors that

favour cotton production, which requires a large amount of hand labour. While the cotton crop yields relatively high returns per acre, other staple crops can be produced as cheaply, or even more cheaply, elsewhere.

Methods of Farm Management.—Until the Civil War, cotton was generally grown under the plantation system with slave labour controlled by an overseer; the planter managing all business transactions and exercising supervision over the crops through his overseer. After the slaves were freed, the “cropper” system came into vogue; so that a plantation now consists of a large area of land worked under one management by croppers or tenants and wage hands.

Plantations having five or more tenants are most numerous in the older cotton-growing eastern States, where the slavery system was well developed prior to the Civil War. Two-thirds of the plantations have from five to nine tenants, a few have fifty or more. The average number of tenants per plantation is ten. The largest plantations are found in Louisiana and Texas. About one-third of the improved land of the most productive cotton lands of the south is in plantations. The size of tenant holdings varies from 25 acres in Louisiana to 60 acres in Texas; the average size is 38 acres.

Croppers.—Although sometimes classed as tenants, croppers are labourers, paid by a share of the crop in place of cash. They are regarded as a higher class than wage hands, and are sometimes distinguished as “half-renters” or “half-hands”. Under the cropper system obviously much less supervision is necessary than is required with wage hands.

The landlord provides the land, implements, work stock, feed, seed, and half the fertiliser. The cropper provides all the labour, half the fertiliser, and pays half the ginning costs. The crops are equally divided between the two. Advances in the form of money and rations are made by the landlord to the cropper, and these are repaid from the cropper’s share of the crop.

Wage Hands.—In addition to the land let to croppers or tenants, owners of plantations generally operate a portion of their lands with the assistance of wage hands, who are commonly paid a monthly cash wage, and are supplied with a house, wood, and rations. Most of the cotton is grown by

the croppers. The wage hands are principally employed in growing the feed crops, and in farm upkeep. In order to hold them on the land during the season, they are sometimes given 2 or 3 acres of land, rent free, which they cultivate with the aid of their employer's work stock, for their own benefit.

Tenant Farms.—Croppers and tenants cannot be sharply divided. The tenant is a more independent farmer than the cropper; where he rents individual farms for cash or on shares, he receives little or no supervision. Tenant farms are found scattered throughout the plantation regions, but outside these regions most of the rented farms may be described as tenant farms.

Some tenants surrender a share of their crops for rent; these usually receive from the landlord one-third and one-fourth of the fertiliser for cotton and maize respectively, while the latter receives in turn from the tenant one-third of the cotton and one-fourth of the other crops. The cost of the ginning is borne in equal parts by the landlord and the tenant.

In certain cases, tenants pay cash for a portion of the land that they rent. Often an agreed quantity of lint is surrendered in lieu of cash; this quantity is frequently 2 500-lb. bales of lint for sufficient land for a 1-mule farm, *i.e.* 10 to 20 acres.

White tenants are most numerous along the northern and western borders of the cotton belt. In these regions, white owners who operate their own farms are also most numerous.

Negro tenants, principally as croppers on plantations, operate more than 21 per cent of all the farms in the south, but few are found in Texas and Oklahoma. They are most commonly met with where plantations are most numerous in the more fertile cotton-growing districts. Negro farm owners are distributed in the same regions as the negro tenants; they operate over 6 per cent of the farms in the south.

According to census returns, three-fifths of the cotton crop is produced by white men, and two-thirds of the farms in the cotton belt are operated by them. In this connection, it should be pointed out that the cotton produced by

negro labourers as wage hands is credited to the white farmers.

Negroes specialise more than white men in cotton production, for, although they operate only 28·7 of the farms, they produce 37·8 per cent. of the crop. Generally the negro tenant grows more cotton than his landlord.

The Cotton Grower's Finances.—Compared with the production of most other agricultural staples, cotton is more dependent upon credit, which the farmer usually procures from the bank or the merchant, and the tenant farmer from the landowner. The merchant is the intermediary between the banker and the farmer; while in the case of the tenant farmer, the landowner either acts as intermediary between the merchant and the tenant or the bank and the tenant.

Merchant credit is essentially unsatisfactory, for the variation between cash prices and time prices is glaringly in excess of the cost of bank credit required for buying similar quantities of commodities.

The Department of Agriculture inquired into this subject in 1921 and reported that in the ten principal cotton producing States the average rate of interest charged, on personal and collateral loans to farmers, ranged from 6·23 to 9·84 per cent. Actually the average rate of interest was a great deal higher than these figures indicate, owing to the practice of collecting interest in advance, which is prevalent among the banks in these States, and of making it obligatory on borrowers to keep a certain deposit at the bank pending the repayment of the loan.

The subject of security for loans is of interest, having regard to the relatively large number of tenant farmers in these States. The prevailing forms of security for loans are personal notes with one or more indorsements, mortgages on live-stock, and crop liens. Warehouse receipts, and stocks and bonds, are seldom utilised for this purpose.

One of the commonest complaints advanced with reference to bank loans to cotton farmers is that the term is generally too restricted for the borrower's credit requirements.

It is considered that economy would result by substituting direct bank credit for merchant credit, also by consolidating the numerous small loans into fewer and larger ones by the

agency of credit associations. Further, the manner in which sufficient capital may be made readily available on favourable terms to the borrower, is for the cotton grower to acquire and maintain his own operating capital.

Climate and Soil.—The cotton belt lies between 25° and 37° N. lat. Although the outstanding differences in yield per acre and density of cotton acreage are primarily due to soil conditions, the outer boundaries of cotton production are almost entirely determined by climatic factors. Along the northern boundary of the cotton belt, the average summer temperature is 77° F. The summer temperature in the southern portion of the belt is 80° to 85°. Along the northern boundary of the belt, the last killing frost in spring usually occurs about the 10th April, and the first killing frost about the 25th October; which gives a frostless period of 200 days. The last killing frost in spring, in the southern portion of the belt, occurs about the 10th March, and the first killing frost of the fall about the 25th November; which gives a frostless period of 260 days.

The average annual rainfall in the cotton belt ranges from 23 inches in western Oklahoma and Texas to 55 inches in North Carolina, and 60 inches in south Mississippi; but throughout much of the belt it is between 30 and 50 inches.

Cotton is grown in practically all types of well-drained soils; the yield is, however, lower on the sandy Uplands, and in wet seasons on heavy clays. The most productive soils are found on the dark-coloured clay lands, and the red, brown, and black river bottoms.

Despite an elaborate system of banks and levees along the Mississippi River, serious loss is often sustained by floods, although the river and its tributaries supply much appreciated moisture. The areas of the inland belt sometimes suffer seriously from drought. In some years, heavy rains occur during the crop-picking season, and cause much damage to the open cotton by beating it to the ground and discolouring it; such damage is appreciably increased when there is a shortage of labour and it is not possible to pick the cotton as soon as it is ripe.

Size of Farms.—Negroes operate the largest farms in the Piedmont region, where they average 48 acres in size, and

have an average of 20 acres under cotton. In this region the farms operated by white owners have an average of 107 acres, of which an average of 17 acres are cultivated in cotton.

Negro croppers' farms in the Yazoo-Mississippi Delta have an average area of 22 acres, and three-fourths of them grow an average of 17 acres of cotton. Relatively few farms are operated by white owners in this region; they have an average area of 223 acres and grow 54 acres of cotton.

In the Alabama-Mississippi Black Prairie, the plantation system with negro croppers prevails. The white owner cultivates less than half as much land as he does in the Delta, while the negro cropper cultivates about the same area of land as in the Delta.

In the Black Waxy Prairies of Texas, more than half of the farms are operated by white tenants; they have an average area of 83 acres with 41 acres under cotton. White owners operate about one-third of the farms in this region. The average area of their farms is 125 acres, and they cultivate about the same area of cotton as the white tenants. Negroes operate only one-eighth of the farms in this region.

More hand labour is required for cotton picking than for any other operation in connection with cotton production. Unless temporary labour is available during the harvest, the area under cotton on a given farm must be restricted to the quantity that the family can pick. Important factors which determine the area to be grown are the size of the family and the extent to which the women and children are utilised for this purpose.

Where the yield is high and extra labour is scarce, the average area of a farm is from 9 to 12 acres. Where lower yields obtain and temporary labour for picking is available, and where machinery is largely employed, the average area of a farm may be as high as 30 to 42 acres.

Average Size of Crops.—The yield of lint per acre varies from about 100 lb. in the dry and weevil-infested districts to over 400 lb. in the best producing districts. The average yield of lint per acre throughout the cotton belt during the ten seasons 1915-16 to 1924-25 was 153.93 lb.

Farms operated by white owners produce the highest yields, and these are followed in order by those of white tenants, negro tenants, and negro owners.

It is specially noticeable that the increased use of commercial fertilisers has largely improved crop production. In the Western States, the good effects resulting from the use of fertilisers, and the adoption of improved cultural methods, have more than compensated for the ravages caused by the boll weevil.

Principal Types of Cotton.—United States cotton may be roughly divided into four main types—short and long staple Upland, Sea Island, and Egyptian. Short staple Upland cotton is grown throughout the cotton belt, and also in the Imperial Valley, California. Its staple varies in length from $\frac{5}{8}$ to 1 inch or slightly more when it is grown under the most favourable conditions. It comprises about 92 per cent of the United States cotton crop, and about 60 per cent of the world's cotton crop.

Long staple Upland cotton is mostly produced in the Yazoo - Mississippi Delta and the adjacent portions of Arkansas, where it comprises one-half of the whole crop. Smaller quantities are also produced in South Carolina, northern Georgia, Alabama, Tennessee, Texas, and in the Imperial Valley, California. Its staple varies in length from $1\frac{1}{8}$ inch to $1\frac{3}{4}$ inch, and the longer of the two competes with Egyptian cotton for certain purposes. Its commercial position is thus between the Upland short staples and Egyptian. The annual production of this type of cotton is about $1\frac{1}{2}$ million bales.

Sea Island cotton is only grown in the islands and mainland of the coast of South Carolina, and inland in southern Georgia and northern Florida. Cotton of Egyptian type is produced in the irrigated areas of southern California and Arizona.

Improved Cultural Methods.—Progress in cotton production is primarily conspicuous in the use of improved machinery for planting and cultivating the crop, the application of measures conducive to the maintenance and increase of soil fertility, and the production and use of improved varieties of cotton. The more extensive use of fertilisers has not only increased the yields of lands ordinarily planted

with cotton, but it has made possible the planting of lands which, owing to their low-yielding propensities, were formerly considered unprofitable for cotton production. It has also been found that the use of fertilisers induces earlier maturity, and this permits the cultivation of cotton farther north than was hitherto possible owing to climatic restrictions.

Divergent Cultural Methods.—Great differences are shown in the methods of land preparation, planting, cultivating, picking, and also in the cost of production of Upland cotton in the various cotton-producing areas of the United States. The reasons for this divergence are not to be altogether attributed to custom, for they have both physical and economic explanations as well.

A profuse growth of pestiferous weeds necessitates more frequent hand hoeing, and this is one of the most laborious tasks of the cotton farmer. In certain regions, the physical characteristics of the land renders the use of large farm implements impracticable. One-mule implements are therefore commonly employed throughout the eastern part of the cotton belt, where these conditions obtain. It is possible for a man with one mule to plough, chop, or thin out seedlings, and hoe from 10 to 20 acres of cotton, and produce from 5 to 10 bales of lint, which is generally as much as one family is able to pick.

High yields are obtained, but labour is scarce, in the Atlantic Coast Flatwoods region, and here the area of cotton per farm is only 9 to 12 acres.

In the black, level, prairie lands of Texas, where crab grass and similar weeds are absent or much less abundant, and consequently less hoeing is required, 4-mule implements are commonly employed to prepare the land, and 2-mule implements to cultivate it. In this region also, temporary labour is available, so that a man, with assistance in thinning out the young plants and in picking the crop, is able to work from 40 to 50 acres of cotton.

In the recently developed cotton-growing areas in the south-west, cultural methods entirely novel to the United States have eventuated. In these regions the land is levelled to admit of the crop being grown under irrigation.

For the production of Sea Island cotton in South Carolina and Georgia, still another method of culture obtains.

Areas planted with Cotton in Different States.—The sub-joined table shows the progress of cotton planting by States:

AREAS PLANTED WITH COTTON, BY STATES, IN SELECTED YEARS (ACRES)
(000's omitted)

States.	Years.					
	1879.	1889.	1899.	1909.	1919.	1924-25.
Texas . . .	2,178	3,935	6,960	9,930	10,476	16,198
Mississippi . . .	2,106	2,883	2,898	3,400	2,848	2,997
Arkansas . . .	1,043	1,701	1,642	2,153	2,725	3,150
Georgia . . .	2,617	3,345	3,514	4,883	5,220	3,183
N. Carolina . . .	893	1,147	1,007	1,274	1,490	1,901
S. Carolina . . .	1,364	1,988	2,074	2,557	2,835	2,236
Alabama . . .	2,330	2,761	3,202	3,731	2,791	3,073
Oklahoma . . .	35	71	683	1,977	2,424	3,791
Tennessee . . .	723	748	623	788	758	986
Louisiana . . .	865	1,270	1,376	957	1,527	1,560
Missouri . . .	35	61	48	106	327	870
Virginia . . .	45	39	26	25	42	89
Florida . . .	246	227	222	263	103	81
Total . . .	14,480	20,176	24,275	32,044	33,566	40,115

Note.—The figures given for Missouri include statistics for other States not named.

Land Drainage.—Three principal types of drainage are employed; their application is governed by the nature of the soil, the amount of rainfall, topography, and land value. They comprise of tile drains, terraces and surface ditches, and open ditches. Tile drains are adopted where the land value warrants the expense of the tiles, and of course in place of open ditches. On rolling land, where the rainfall is heavy, surface ditches and terraces are employed to carry off surface water, and to check erosion. On poorly drained flat lands open ditches are employed. This method is uneconomical, for the ditches occupy a considerable area of land which would otherwise be available for cultivation.

Land Preparation for Planting.—Throughout the cotton belt, cotton usually follows maize or cotton in the scheme of planting; so that, except where the stalks do not grow sufficiently large to impede tillage operations, it is necessary before ploughing to break up the stalks left behind by the

preceding crop. A stalk-cutting machine is generally used for this operation, unless the stalks have made unusually rank growth, and weeds are abundant, when a disc harrow is likewise employed.

Prior to ploughing, tillage operations are conducted primarily with the object of cutting up and disposing of the stalks and weeds of the preceding crop. Little regard is paid to the advantages that accrue from pulverising the surface soil before ploughing.

Ploughing is carried out either in the autumn or in the spring, according to the type of soil and the previous crop. Heavy clay soils are more frequently ploughed in the autumn than light, sandy soils. Autumn ploughing is usually slightly deeper than spring ploughing. Most of the land is ploughed in the spring; this is partly because the heavy winter rains are more likely to cause erosion on ploughed land, especially on rolling lands with a clay soil, and partly because the previous crop is not harvested sufficiently early in the autumn to permit of ploughing being carried out at that season.

The ploughing depth is usually from $4\frac{1}{2}$ to 6 inches. Investigations indicate that there is little relation between the depth of ploughing and the yield of seed cotton per acre.

Cultivation.—Sub-soiling is generally effected by ploughing a furrow with an ordinary turning plough, afterwards running a smaller shovel plough in the bottom of this furrow. Where beds are prepared for cotton, sub-soiling is only employed in the furrows immediately under the rows.

Subsequent cultivation is carried out with spike tooth and disc harrows. Generally the land is bedded with the turning plough, but the middle buster or lister is also employed for this purpose. The mouldboard of a middle buster resembles the mouldboards of a right hand and a left hand turning plough fastened together.

Fertiliser is generally applied to cotton land by means of a fertiliser-distributing machine. Between ploughing and planting, the land receives two or three workings, of which that of the fertiliser distributor is reckoned as one working. Sometimes a combined planting and fertiliser-distributing machine is employed, and the fertiliser is applied at the time

that the cotton seed is planted. The average number of cultivations given to cotton after planting is five or six.

Fertiliser Application.—Fertilisers are most largely used on the soils of the Atlantic Coastal Plain and the Piedmont Plains of North and South Carolina and Georgia. They are also extensively used in the southern States. Comparatively little fertiliser is used in the western districts of the cotton belt, but it is becoming more popular there.

In many cases, fertiliser purchase constitutes the greatest cash outlay in connection with cotton production. In the eastern States it ranks only second to labour in cotton production costs.

Superphosphate, kainit, cotton-seed meal, muriate of potash, and nitrate of soda are the fertilisers most commonly favoured. Other fertilisers less frequently used are dried blood, basic slag, rock phosphate, fish scrap, and tankage.

A mixture that is commonly applied to sandy loams that are deficient in potash, consists of equal parts of cotton-seed meal, acid phosphate, and kainit. This is applied at the rate of from 300 to 1000 lb. per acre. In the Coastal Plains and the Piedmont, nitrate of soda is often applied, in addition, at the rate of from 50 to 100 lb. per acre.

Seed Planting.—In the southern portion of the cotton belt, seed planting usually begins about the 20th of March, in the central portion during the first week in April, and in the northern portion about the 20th of April. The planting season in any one region extends for two or three weeks.

The seed is usually planted on a slightly raised bed, for it is then easier to thin out the young plants than when the seed is planted on level land. Further, when the land is bedded up, more surface is exposed to the air and sunshine, better drainage conditions are afforded, the soil warms quicker, and as a result plant growth is accelerated.

Seed is planted at the rate of from 15 to 30 lb. per acre, always in drills, which range from 3 to 4 feet apart. It is customary to plant the seed with a one-horse, one-row planter, although in some areas of Oklahoma and Texas, two-horse, one-row planters are in vogue. Very little cotton is planted by hand.

Thinning or Chopping out Seedlings.—When the plants are a few inches high, either at the first or the second cultiva-

tion, they are thinned out by hand with a hoe, leaving one or two plants to a stand or hill, with a space of from 12 to 18 inches between the stands. This process is known as "chopping out" and, next to picking, it is the most laborious task of the cotton farmer.

In the southern portion of the cotton belt, thinning out begins about the 1st of May, and continues for about a month. In the northern portion of the cotton belt it begins about a month later.

At the third or fourth cultivation, it is usual to go over the rows again to remove with the hoe any weeds and extra cotton plants that may have been overlooked at the first thinning.

In view of the divergency shown in the cultural methods practised in the different sections of the cotton belt, it is of interest to compare the methods prevailing, in a representative centre of the older cotton-growing regions of the east, with those of a centre in the newer cotton-growing regions of the west.

Eastern Cultural Methods. —Barnwell County is situated in the south-western portion of South Carolina, in the Coastal Plain. The land is generally rolling, and the prevailing soil is a sandy loam with a clay sub-soil. Little drainage is necessary. Some of the rolling lands are drained by surface ditches and terraces, while the lower-lying lands are drained by open ditches which surround the fields.

The most prevalent and troublesome weeds are: Bermudas grass, crab grass, cocklebur, nut grass, and wild coffee.

The average size of the farms is about 193 acres, of which 130 acres is improved land; these are mostly owned by white men, and are largely worked by negro tenants.

Cotton, maize, and oats are the crops most favoured, but definite rotations are not practised. Often cotton is grown on the same land for two years, and is followed by maize for one year. Ground-nuts or cowpeas are frequently planted between the maize rows, and when they mature, pigs are turned on the land to feed on them.

Pigs are raised in sufficient numbers only to supply the home, and few cattle are kept.

Cotton furnishes practically the sole source of income from the farm.

In the preparation of the land for cotton cultivation, the old cotton or maize stalks are cut down with a stalk-cutting machine, or are broken down by hand with a stick, during the winter months. In the early spring the land is broken level with one-horse or two-horse ploughs, the depth of ploughing being 6 inches. Any further levelling required is done with a disc harrow.

The rows are then laid off with a one-horse shovel plough. In the furrows thus formed, fertiliser is applied with a distributor. By throwing a furrow from each side, with a turning plough, a bed is formed on the fertiliser.

About 660 lb. of commercial fertiliser are applied per acre. Half of this is applied before the seed is planted, and the balance at the second or third cultivation. Frequently nitrate of soda is used as a top dressing, and this is applied at the second or third cultivation. Farmyard manure is little used. No cover crops are grown, but a certain quantity of organic matter is supplied to the soil by the ploughing in of weeds and crop residues.

A one-horse planter is employed to plant the cotton seed, in rows 4 feet apart, at the rate of 30 lb. per acre. The planter breaks down the bed, and leaves the seed planted only a few inches above the ground level.

One-horse sweeps or scrapes are employed for cultivating. About two weeks after planting, the first cultivation is given with a 20-inch sweep cultivator, two furrows being given to each row.

Before the second cultivation, the young cotton plants are thinned out by hand with the hoe, to from 12 to 18 inches apart in the row.

The rows are usually gone over twice with the hoe after thinning out the plants, to eliminate weeds and extra cotton plants. Hoeing is generally performed by women and children.

At the second cultivation, two furrows to the row are given with a 22-inch sweep cultivator, and one furrow in the middle of these two with a one-horse 8-inch shovel plough.

Subsequent cultivations are given with one-horse 22-inch and 24-inch sweeps. Altogether six or seven cultivations are given.

The commonest varieties of cotton grown are King's and Cook's Improved, and Toole ; these are all Upland varieties.

The average yield of seed cotton per acre is 925 lb.

Western Cultural Methods.—Ellis County is situated in the north-western portion of Texas, and it is one of the most prosperous agricultural counties in the State. It is favoured with very fertile soils, and the seasons are generally propitious. A belt of prairie country traverses the central portion, with broad, gently rolling land of Houston black clay soil, which requires little drainage.

Each year, 80 per cent of this land is cultivated with cotton. No crop rotations are practised, but oats and maize are grown for cattle food. In the eastern and western portions of the county, cotton also is the principal commercial crop. Only a few cattle and pigs are kept. With the exception of cotton, few farm products are sold. The commonest and most troublesome weeds are : Johnson, hurrah and careless grass, cocklebur and morning glory.

Most of the rural population consists of white Americans. The farms are of medium size, and they are worked either by the owners, or by white tenants who supervise their own work. Improved labour-saving implements and heavy teams are extensively used. One man is thus able to work from 50 to 60 acres of cotton, with assistance in thinning out the young plants and picking the crop ; for ample negro labour, men, women, and children, is procurable from the neighbouring cities for the extra work.

In the preparation of the land for cotton planting, it is ploughed about $5\frac{1}{2}$ inches deep, with a four-horse middle buster or lister, during the late winter or in the early spring. Only one furrow is required for each row with this implement. The soil is thrown up into beds as wide apart as the cotton rows are to be planted. If the stalks of the previous crop are rank, they are cut up with a stalk cutter, when ploughing is done, or they are raked up after ploughing and burned. Prior to planting, the beds are harrowed once with a spike-tooth harrow.

The seed is planted, at the rate of from 15 to 22 lb. per acre, in rows 3 feet apart, with a two-horse, one-row lister planter. This planter is equipped with a broad shovel that

tears down the bed, and leaves the cotton planted almost in the level ground.

All subsequent cultivation is carried out with a two-horse, one-row, four-shovel cultivator, which is fitted with buzzard wing sweeps in place of shovels. The first cultivation takes place ten or fourteen days after planting; for this operation, 6-inch or 8-inch sweeps are used next to the cotton, and 10-inch or 12-inch sweeps on the outside.

Plant thinning takes place after the first cultivation, the plants being left from 12 to 15 inches apart in the rows. The cotton rows are gone over with the hoe once or twice later in the season, to remove extra cotton plants and weeds.

The same cultivator is used for subsequent cultivations, but 12-inch, 14-inch, and 16-inch sweeps are used. Level cultivation is always practised. Four or five cultivations are given during the season.

Owing to the richness of the soil, little fertiliser is used. The small amount of stable manure that is produced is scattered over the poorer patches in the fields. Mebane and Rowden are the varieties of cotton most generally grown. The average yield of seed cotton is 676 lb per acre.

The Yield of Cotton.—In the cotton belt, inherent soil fertility and climatic conditions are the primary factors which determine the yield of cotton. There is, however, a direct correlation between the amount of cultivation which cotton receives after planting and the yield of seed cotton per acre. A study of the practice of crop rotation usually discloses the fact that the best results accrue from the rotations that have the greatest proportion of crops which add organic matter to the soil, such as hay or pasture.

In the districts where heavy annual applications of commercial fertiliser are made, and where from 40 to 50 per cent of the cultivated land is under cotton, an increase in yield is noticeable.

Investigations carried out by the United States Department of Agriculture, in connection with some 475 farms in different areas throughout the belt, show that in the nine areas having the highest yields of cotton the practice of applying commercial fertilisers obtained on 70 per cent of the farms surveyed. The average application of fertiliser per acre for cotton was found to be 408 lb. In the nine areas which have

the lowest yields of cotton, fertiliser was only found to be in use on 43 per cent of the farms surveyed, and on these the average application of fertiliser for cotton was 251 lb. per acre. Having regard to all the farms that were surveyed, it transpired that in the nine areas that have the highest yield of seed cotton per acre, the farms gave an average normal yield of 954 lb. per acre, while in the nine areas that have the lowest yield of seed cotton per acre the average is 628 lb.

There was found to be little correlation in the price of the land and the yield of cotton per acre. The average value of the land for the nine areas which have the highest yield of seed cotton is \$64.50 per acre, while the average value for the nine areas which have the lowest average yields of seed cotton per acre is \$55 per acre.

In 1923 the average yield throughout the cotton belt was 131 lb. of lint per acre, which was close to the averages of the two preceding years.

Picking.—A heavy duck sack is mostly used for cotton picking; it measures about 8 feet long by 24-30 inches wide. This is either tied round the waist or suspended at the waist by a long strap hung over the right shoulder, so that the mouth of the sack is on the left side just above the hip. The length of the sack permits it to drag along the ground behind the picker, relieving him of the weight of its contents, and allowing him freedom of movement in bending over the plants. The sack holds about 40 lb. of seed cotton.

As the picker moves from plant to plant, he grabs the bag at the back of him with one hand and drags it along the ground. It is usual to pick one row at a time, so that the bag is dragged between two picked rows. He uses both hands to pick independently of each other. The cotton is not detached from the boll by a straight pull; the fingers and thumb fit into the lock of the boll, and the hand is given a twisting or levering motion to bring the cotton away. A good picker plucks the contents of three or four bolls and keeps it in his hand before transferring it to the bag, and does not leave any cotton behind in the bolls. Good pickers can collect from 150 to 200 lb. of seed cotton in a day.

Picking is not delayed until the morning dew has dried off, but dew-moistened cotton is spread on tarpaulins to dry. Whenever possible, picking takes place before the cotton is in

a condition to be blown about by wind or storm to become mixed with foreign matters, also before its bloom and character are injured by undue exposure to sunlight.

Crop Forecasts.—The crop reports of the Bureau of Crop Estimates are based on data obtained through a field service comprising a corps of paid State field agents and crop specialists, and a large number of voluntary crop reporters. The latter consist of county reporters, township reporters, and individual farmers. A trained field agent is assigned to each State or group of smaller States. Each agent travels through his State during the crop season, personally inspects crop areas, and confers with the State and local authorities, private and commercial agencies, and others interested in crop reporting work. His own observations are supplemented by reports from a corps of selected crop reporters in his State ; these are quite independent of the crop reporters, who report direct to the Bureau.

Besides the field agents, there are attached to the Bureau a number of crop specialists ; these specialise on particular crops, and they travel throughout the districts where the crop in which they are interested is grown. The crop specialists also have selected lists of crop correspondents who report directly to them. The field agents and the crop specialists are appointed by the Civil Service Commission after a rigid competitive examination. Of the voluntary crop reporters who report directly to the Bureau at Washington, there are about 2800 principal county reporters and 32,000 township reporters. Important information is obtained from some 30,000 mills and elevators. Reports on their own operations are furnished by a large number of individual farmers.

The reports on the cotton crop are dealt with separately from other crops because of the specialised nature of this crop. Besides the regular estimates of the ordinary reporting authorities, reports on acreage are obtained by the Bureau, as well as on yields, ginning percentage, etc., from many thousands of special reporters who are intimately connected with the crop.

The Bureau tabulates and compiles the reports received from the different correspondents, and the figure for each State is computed. The compilation of the final crop

estimates culminates at sessions of the Crop Reporting Board, which comprises five members. The Chairman of the Board is the Chief of the Bureau, and the members are selected from the statisticians and officials of the Bureau and the field agents and crop specialists. Every month the personnel of the Board is changed. Great precautions are taken to prevent the information contained in the Board's reports leaking out prematurely, and also to ensure that they issue simultaneously throughout the country. There are 2800 counties of agricultural importance in the United States, and the Department has a principal county reporter in each who maintains an organisation of several assistants.

Cotton reports are issued on or about the first day of each month during the growing season, and are published throughout the United States within twenty-four hours.

Handling the Crop.—Throughout the centre of the cotton belt, practically all the cotton is ginned before it is marketed by the producer. But on the borders of the cotton belt, much of the crop is sold as seed cotton. The latter procedure is most prevalent where little cotton is produced. When the cotton industry was in its infancy, gins were owned and operated by the large plantations, but as the industry developed and small farms became more numerous, public or custom gins were established. Such plantation gins as still exist also generally function as public gins. Wherever sufficient cotton is produced to warrant their upkeep, public ginneries have now been established. In the season 1920–21 there were 18,440 ginneries in operation, which ginned an average of 720 bales each.

A charge is made for ginning by the 100 lb. of seed cotton, with an additional charge for the bagging and ties used in making up the bales of lint. After a grower's cotton is ginned he may elect to have his seed returned to him, or to sell it to the ginner or to an agent of one of the oil mills.

As the lint comes from the gins it is pressed into bales, that are covered on two sides and on the ends with bagging, and tied with six steel bands. Most of the crop is baled in a press box 54 inches long by 27 inches wide and 45 inches deep, which makes the standard flat or square bale of about 500 lb. in weight. Cylindrical or "round" bales are made to a certain extent in the western part of the cotton belt. These

are completely covered with bagging ; they measure approximately 35 inches long by 22 inches in diameter, and weigh about 250 lb.

Sea Island cotton is made up into bales $7\frac{1}{2}$ feet long by $2\frac{1}{2}$ feet in diameter, and weigh approximately 350 lb.

The standard square 500-lb. bale has the relatively low density of only 12 to 15 lb. per cubic foot, and besides it is unwieldy and is not, therefore, economical of railway and ship space.

At interior markets and railway concentration points "compresses" have been established, where the standard bales are subjected to recompression and the original size of the bale is reduced by one-half. The cylindrical and the square gin-compressed bales have a density of 32 to 37 lb. and 35 lb. per cubic foot respectively.

High density compresses have been established at some of the concentration points and ports, such as Augusta, Galveston, Houston, Mobile, and New Orleans, which increase the density of the bale to 35 lb. and more per cubic foot.

Where no compressing facilities exist at the points of origin, the railway companies have it compressed *en route* to destination. For this service a charge of about 12 cents per cwt. is made, and additional charges for patching the bales. All such charges are added to freight charges and are collected by the railway companies.

Bolly and Snap Cotton.—Many of the bolls of cotton plants that have been injured by frost do not develop properly. These bolls are collected and put through machines, which separate the seed cotton from the burrs. The resultant seed cotton is then dealt with in a similar manner to that picked by hand. The lint produced therefrom is generally immature, and is usually light, fluffy, and soft ; it is known in the trade as "bolly cotton", and sells at a lower rate than properly matured lint.

Of recent years, difficulty has been experienced through labour shortage in picking all the cotton at the proper time. Some of it has therefore been left unpicked until the late autumn or winter. It is then found more expeditious to snap the bolls off the plants than to pick the cotton. These bolls are then treated similarly to the bolly cotton. The lint

is known as "snaps". Its spinning value is superior to that of bolly cotton, but as it is discoloured and trashy through exposure, it likewise realises a comparatively low price. In 1919 the production of snaps and bollies was 356,000 and 141,000 bales respectively.

Linters.—Linters is the name given to the fuzz or felt-like covering peculiar to the seeds of many cultivated varieties of cotton, which is removed by a second and more intensive ginning process known as delinting. This process is usually conducted at the oil mills in the preparation of the seed for crushing; in addition to fuzz, it removes any long fibres that escaped the first ginning operation.

Linters are baled in the same way as ordinary cotton. The total production of linters in 1924-25 amounted to 750,000 bales. During the World War a considerable quantity of this material was employed in the manufacture of explosives, so that in the seasons 1916-17 and 1917-18 over $1\frac{1}{4}$ million bales of linters were produced. During the last twenty years the ratio of linter production to cotton production has been 4.37 per cent.

In normal times their felting qualities and chemical composition enable them to be employed in the manufacture of many articles, such as stuffing material for cushions, horse collars, mattresses, and upholstery, mixing with wool for hat-making, and with lamb's wool for fleece-lined underwear, lamp and candle wicks, rope, twine, and carpets, writing paper, also for varnishes, artificial leather, celluloid, artificial silks, and photographic films.

Cotton Seed.—Approximately two-thirds of the weight of cotton, in the condition in which it is picked and delivered to the ginnery, comprises seed. Practically the whole of the seed, apart from that required for planting, finds its way to the oil mills, where it is crushed and the oil is extracted.

Oil mills have now been established in all the principal cotton-producing centres, for the bulky nature of the seed renders long-distance transport unprofitable. To-day there are about 850 oil mills in operation.

At the oil mills the seed is first cleansed of dirt and trash, and is then passed through a delinting machine to remove the fuzz. Next it is passed through cutting and crushing

machines, which break up the seed and separate the shells or hulls from the kernels. The kernels are subsequently passed through hydraulic presses to extract the oil from them. The residue is cotton-seed cake, which when ground becomes cotton-seed meal. In what are known as the cold press mills, the whole seed is crushed without removing the shells from the kernels.

Warehousing.—Cotton storage warehouses have been established throughout the south and in the eastern States, both at the local markets and at the principal concentration points. Comparatively few exist in Arkansas, Oklahoma, Texas, Tennessee, Mississippi, and Louisiana, where the bulk of the crop is marketed shortly after it is ginned, and is shipped direct to the mills or exported.

These warehouses not only afford protection from the weather but from fire and theft as well. In addition, they provide facilities for classing and assorting the cotton for market. Further, farmers who avail themselves of their use are able to procure cash advances on their crops until they are sold, for warehouse receipts represent one of the most appreciated forms of security. The Federal Warehouse Act, 1916, facilitates the holders of warehouse receipts in borrowing money to enable them to proceed with their operations, while holding their cotton for favourable markets.

The United States Official Cotton Standards for Grade.—The cotton consumer appraises the lint not only in accordance with the length, strength, and uniformity of the staple, but likewise by its colour and the quantity of foreign matter that it contains. Owing to the confusion that prevailed in the marketing of cotton, because of the circumstance that practically every market had its own grades, and as these were often altered to accord with special crop conditions, the Department of Agriculture was authorised to prepare grade standards. This procedure had for its primary objective the simplification of cotton marketing, by providing a single set of standard grades on which quotations, sales, and purchases could be based. Copies of the official cotton standards for grade are on sale. A full set of white standards comprises nine boxes, each of which contains twelve samples of the same grade of cotton. The twelve samples in each box indicate the range of diversity allowed within the grade.

“ Middling ” is the middle or basic grade, and is the grade upon which the market quotations are based.

In 1921 the exchanges of practically all the leading cotton markets in the United States had adopted the standards. About 2500 complete and fractional copies had been distributed to the American cotton trade, and in addition to most foreign markets.

The passage of the United States Cotton Standards Act of 4th March 1923 requires the use of the official cotton standards of the United States in interstate and foreign commerce. At a conference in Washington in June 1923, which was attended by representatives of all the leading cotton exchanges of Europe, the American cotton trade, and officials of the United States Department of Agriculture, it was agreed that these standards for grade and colour, with some slight modifications, should be adopted as uniform standards for American cotton. It was agreed that, in so far as commerce in American cotton is concerned, the whole world will use identical names to represent standard qualities. Contracts covering the agreement, and rules under which the foreign trade in American cotton is to be conducted, have been signed by the Liverpool, Manchester, Havre, Bremen, Barcelona, and Rotterdam Cotton Associations. It was anticipated that this agreement will enable international cotton business to be greatly simplified, and the cause for disputes and reclamations largely eliminated, for the same standard will be applied to the cotton from the time that it leaves the farmer until it reaches the spinner in any part of the world. The path between the producer and the consumer will be shortened, and will result in the farmer receiving a larger share of the proceeds from the sale of his cotton to the spinner. Regulations of the Secretary of Agriculture under the United States Cotton Standards Act were published in August 1923.

Crop Deterioration.—The United States and European cotton trade have been unanimous in their testimony as to the deterioration of American cotton during recent years. It is considered that this retrograde tendency is in a measure due to the planting of many different varieties in the same district, the planting of ordinary mixed “ gin run ” seed, and the resulting cross-fertilisation that has taken place in the

field. Another factor, which is also conducive to this deterioration, is the lack of discrimination exhibited by buyers in the primary markets, and their failure to recognise superior-quality cotton in their dealings with the growers. This has had the effect of influencing farmers in the belief that the most desirable character in a cotton variety is a high percentage of lint. Whereas a high lint percentage is frequently associated with short and inferior lint, as well as with small seeds which yield a low percentage of oil.

Cotton Markets.—The distribution of the cotton crop requires an extensive system of transporting and markets. The bulk of the crop produced in the South Atlantic States is consumed in the southern mills, the balance of the crop being conveyed, by railway or water, to the northern mills or abroad.

The producer sells his crop to one of the various dealers or to the mills direct. The price that he receives is not only affected by supply and demand at centres of consumption, but likewise by the cost of handling from the producer to the mills, middlemen's profits, and the producer's ability to profit by adopting the most economical methods of marketing his crop.

Cotton trading may be done in actual cotton, or in contracts for future delivery on a specified date; the former is known as the "spot market" and the latter as the "future market".

The spot market is comprised of both primary and interior markets. The villages and towns where baled cotton is first offered for sale by the producer, constitute the primary markets. The large towns and cities where cotton purchased in the primary markets is received and sold to merchants or mill agents, are designated as interior markets. It is at the latter that the cotton is usually graded, compressed to economise storage and railway space, collected into commercial lots, and consigned to the consumption centres.

Future markets or exchanges are in New York and New Orleans, where much of the cotton dealt with is never seen. The most important foreign future market for American cotton is Liverpool, but future markets also exist at Bremen and Havre.

The export markets, where cotton is sold and exported, are found in the cities on the Atlantic and Gulf Coast. Boston, New York, and Philadelphia are both export and important consuming markets as well.

All markets are intimately associated through the dealers' operations. The future markets virtually determine prices, for the prices quoted in all the other markets are based on the future quotations.

Buying takes place in the primary markets as soon as ginning commences, for a great deal of the cotton is grown under mortgage, and it has to be quickly disposed of in order to meet financial obligations. Much of the cotton is also pledged in advance by tenants, who early dispose of their crops to the plantation owners, merchants, or representatives of large dealers.

The farmer who is able to hold his crop and does so, must perforce bear the expense of storage, insurance, and the loss of potential interest on the capital involved. On the other hand, the purchaser, who buys larger quantities of cotton than can be transported or consumed at once, has to bear these charges, and he reduces his purchase price accordingly. Dealers are able to buy and hold large stocks of cotton, or to transport it long distances, without incurring undue risks, for the operations of the future exchange enable them to cover themselves by hedging.

The quotation for "Middling" cotton, on the nearest active trading month, on the future exchanges, is the recognised basis for price quotations on all the markets. A deduction from the price quotations has to be made at primary markets to cover handling and transport expenses.

Grades are frequently not well recognised in small primary markets, and classifications may not be carefully made, so that producers depend upon the buyers' grading of the cotton, and make the best possible terms with them for its sale. Provided that buyers are numerous, fairly close grading obtains, and the prices offered permit only a reasonable profit to the buyer.

Grading has become standardised in the large, primary, and interior markets, and at each market the grades below and above "Middling" are settled for in accordance with

the differences prevalent in that market. Otherwise the prices in these markets are determined in the same manner as in the smaller primary markets.

“ Middling ” is the basic grade in “ Futures ” contracts, and the price quoted in the contract is for that grade. In the event of grades other than Middling being delivered, the buyer pays as much above or below the contract price as the grades delivered are worth.

In accordance with the United States Cotton Futures Act, certain *bona fide* spot markets, appointed by the Secretary of Agriculture, report daily to him and to the United States future exchanges, the prevailing price for Middling and the other grades “ on ” (above) and “ off ” (below) Middling.

Cost of Production.—The United States Department of Agriculture has undertaken comprehensive investigations with regard to the cost of cotton production. The first of these was conducted in connection with the crop for 1918, on 842 farms in representative cotton-growing counties in Alabama, Georgia, South Carolina, and Texas. In respect of the crop for 1919, similar investigations were conducted on 821 farms in Alabama, Arkansas, Georgia, Mississippi, South Carolina, and Texas.

The investigators rightly emphasise the fact that, as money costs fluctuate appreciably, they do not provide a satisfactory basis for comparison throughout a period of years. Items of cost that remain fairly constant from year to year, can be utilised more effectively than costs reported in dollars and cents. Factors possessing this stability are known as “ the basic requirements of production ”. They include the hours of man and mule or horse labour employed in growing the crop, the quantity of seed and fertiliser used per acre, and the quantities used of such other materials as are required in cotton production. The basic factors of production therefore constitute the fundamental data for the conclusions propounded.

With regard to the investigations during 1918, production costs were summarised under three groups: labour costs, material costs, and other costs.

Labour costs include man and mule labour. The rates for man and mule labour are quoted as 30 and 12 cents per hour respectively.

SUMMARY OF LABOUR COSTS (842 RECORDS)

State and County.	Number of Records.	Total Number of Acres in Cotton.	Yield of Lint per Acre.	Labour Cost per Acre.			Labour Cost per lb. of Lint.
				Man.	Mule.	Total.	
			lb.	\$	\$	\$	\$
Georgia :							
Laurens County . .	85	3968-0	277	45-09	7-22	52-31	0-1887
Greene	78	4147-5	260	43-39	7-15	50-54	0-1945
Sumter	80	4188-5	244	32-78	7-66	40-44	0-1657
Alabama :							
Tallapoosa . . .	89	1169-0	172	47-41	7-10	54-51	0-3163
Marshall	90	1249-5	227	50-76	7-12	57-88	0-2554
Dale	90	1226-5	194	40-96	6-42	47-38	0-2445
S. Carolina :							
Anderson	89	2865-5	248	43-41	6-80	50-21	0-2026
Barnwell	91	3935-5	268	41-52	7-51	49-03	0-1832
Texas :							
Ellis	75	8148-0	176	17-51	4-42	21-93	0-1242
Rusk	75	2568-0	185	29-33	5-89	35-22	0-1900

Material costs comprise cotton seed used in planting, farmyard manure and commercial fertiliser applied to the cotton land, and baskets, sacks or sheets, used in harvesting the crop.

SUMMARY OF MATERIAL COSTS (842 RECORDS)

State and County.	Number of Records.	Total Number of Acres in Cotton.	Yield of Lint per Acre.	Material Costs per Acre.					Material Cost per lb. of Lint.
				Seed.	Manure.	Fertiliser.	Sacks and Sheets	Total.	
			lb.	\$	\$	\$	\$	\$	\$
Georgia :									
Laurens County . .	85	3968-0	277	1-27	0-04	3-85	0-24	5-40	0-0195
Greene	78	4147-5	260	1-75	0-36	4-17	0-18	6-46	0-0248
Sumter	80	4188-5	244	2-05	0-44	4-92	0-22	7-63	0-0313
Alabama :									
Tallapoosa	89	1169-0	172	1-60	0-32	3-07	0-18	5-17	0-0300
Marshall	90	1249-5	227	1-72	1-90	6-43	0-25	10-30	0-0455
Dale	90	1226-5	194	1-69	0-39	3-54	0-26	5-88	0-0303
S. Carolina :									
Anderson	89	2865-5	248	1-70	0-46	5-93	0-12	8-21	0-0331
Barnwell	91	3935-5	268	1-48	0-46	11-24	0-23	13-41	0-0501
Texas :									
Ellis	75	8184-0	176	1-14	0-01	..	0-05	1-20	0-0068
Rusk	75	2568-0	185	1-12	0-02	2-11	0-27	3-52	0-0190

Other costs include such items as interest or land rent, insurance and taxes, machinery charges and overhead expense.

SUMMARY OF OTHER COSTS (842 RECORDS)

State and County.	Number of Records.	Total Number of Acres in Cotton.	Yield of Lint per Acre.	Other Costs per Acre.					Other Costs per lb. of Lint.
				Use of Land.	Insurance and Taxes.	Machinery.	Over-head.	Total.	
			lb.	\$	\$	\$	\$	\$	\$
Georgia :									
Laurens County .	85	3968-0	277	7-38	0-30	1-69	5-77	15-14	0-0546
Greene . . .	78	4147-5	260	7-47	0-17	1-64	5-70	14-98	0-0576
Sumter . . .	80	4188-5	244	6-76	0-25	1-62	4-81	13-44	0-0551
Alabama :									
Tallapoosa . .	89	1169-0	172	3-10	0-13	1-59	5-97	10-79	0-0626
Marshall . . .	90	1249-5	227	9-32	0-25	2-63	6-82	19-02	0-0840
Dale	90	1226-5	194	5-25	0-20	1-63	5-32	12-40	0-0640
S. Carolina :									
Anderson . . .	89	2865-5	248	11-80	0-28	1-57	5-84	19-49	0-0786
Barnwell . . .	91	3935-5	268	7-22	0-15	1-67	6-24	15-28	0-0571
Texas :									
Ellis	75	8148-0	176	16-83	0-44	1-48	2-31	21-06	0-1193
Rusk	75	2568-0	185	5-15	0-28	1-72	3-87	11-02	0-0594

On the following page is given a summary of all costs ; the cotton seed produced is considered as a by-product and is credited at current market rates.

An analysis of the percentage distribution of costs furnishes additional and instructive information on the subject.

DISTRIBUTION OF COSTS (842 RECORDS)

State and County.	Number of Records.	Total Number of Acres in Cotton.	Yield of Lint per Acre.	Percentage of Total Cost to :			
				Labour.	Material.	Ginning.	Other.
			lb.				
Georgia :							
Laurens County .	85	3968-0	277	70	7	3	20
Greene	78	4147-5	260	68	9	3	20
Sumter	80	4188-5	244	64	12	3	21
Alabama :							
Tallapoosa . .	89	1169-0	172	76	7	2	15
Marshall . . .	90	1249-5	227	65	12	2	21
Dale	90	1226-5	194	71	9	2	18
S. Carolina :							
Anderson . . .	89	2865-5	248	63	10	3	24
Barnwell . . .	91	3935-5	268	61	17	3	19
Texas :							
Ellis	75	8148-0	176	47	3	4	46
Rusk	75	2568-0	185	68	7	4	21

In connection with these summaries, it is to be observed that the net cost per acre increases as the yield of cotton

SUMMARY OF ALL COSTS (842 RECORDS)

State and County.	Number of Records.	Total Number of Acres in Cotton.	Yield of Lint per Acre.	All Costs, including use of Land.						Total Net Cost.		
				Labour.	Material.	Ginning.	Use of Land.	Miscellaneous Cost.	Total per Acre.	Total per lb. of Lint.	Seed Credit per Acre.	Per lb. of Lint.
			lb.	\$	\$	\$	\$	\$	\$	\$	\$	\$
Georgia:												
Laurens County	85	3968-0	277	52-31	5-40	2-14	7-38	7-76	74-99	0-2705	15-55	0-2144
Greene	78	4147-5	260	50-54	6-46	2-09	7-47	7-51	74-07	0-2850	15-81	0-2242
Sumter	80	4188-5	244	40-44	7-63	1-92	6-76	6-68	63-43	0-2599	15-35	0-1970
Alabama:												
Tallapoosa	89	1169-0	172	54-51	5-17	1-39	3-10	7-69	71-86	0-4169	10-31	0-3571
Marshall	90	1249-5	227	57-88	10-30	1-94	9-32	9-70	89-14	0-3934	13-72	0-3329
Dale	90	1226-5	194	47-38	5-88	1-62	5-25	7-15	67-28	0-3472	13-17	0-2792
S. Carolina:												
Anderson	89	2865-5	248	50-21	8-21	1-97	11-80	7-69	79-88	0-3223	14-80	0-2626
Barnwell	91	3935-5	268	49-03	13-41	2-07	7-22	8-06	79-79	0-2981	14-13	0-2453
Texas:												
Ellis	75	8148-0	176	21-93	1-20	1-82	16-83	4-23	46-01	0-2607	9-78	0-2053
Rusk	75	2568-0	185	35-22	3-52	1-79	5-15	5-87	51-55	0-2781	10-19	0-2231

increases, while the net cost per lb. of lint decreases ; or, in other words, an increased yield is an important factor in reducing unit cost. The twenty-four farms that had a yield of 100 lb. and under of lint per acre had a net cost of \$49·30 per acre, and a net cost of 57 cents per lb. of lint. The fifty-three farms which produced over 300 lb. of lint per acre had a net cost of \$80·65 per acre, and a net cost of 22 cents per lb. of lint.

Where it is possible to make proper comparisons, it appears that the farms which produce the larger acreages of cotton have the lower unit costs ; especially is this noticeable in comparing the farms producing 20 acres of cotton and under with those which had 20 to 40 acres. Of course it does not necessarily follow that the cost is altogether controlled by the area of the farm, for the human factor has to be considered, and it is probable that the lower costs on the larger farms are associated, to a certain extent, with the superior ability of their operators.

During the year 1918 the average yield for all cotton produced in the United States was 155·9 lb. of lint per acre. This was about 20 lb. lower than the average yield for the ten years 1909–1918. The average yield of lint for the 842 farms which were the subject of these investigations was 227 lb. per acre ; it was thus both higher than the average normal return for the year, and of the ten-year average, for the whole cotton belt.

The average cost of production was 23 cents per lb. of lint. The bulk of the lint was produced for 28 cents per lb. or less. The range in cost was extremely wide, 8 cents to \$1·07 per lb. of lint.

The average price which the farmers received for their lint was 29 cents per lb. ; the range in prices received varied from below 20 cents to 43 cents per lb. of lint ; 80 per cent of the cotton sold for prices varying from below 25 cents to 32 cents per lb.

In the areas of cotton cost investigations for the seasons 1918 and 1919, the sum of the charges made for man and mule labour, fertiliser, and seed constituted from 78 to 86 per cent of the total operating expense ; the balance was made up by equipment, taxes, insurance, ginning, and overhead charges. By the application of current prices to the amounts of labour,

fertiliser, and seed consumed in the production of cotton, approximate results may be obtained in estimating the cost of production at any given period by using these proportions.

It is important to bear in mind that the scope of the investigations embraced only a relatively small portion of the total cotton area of the United States; the conclusions to be drawn from them are therefore only applicable to the farms of the cotton belt in general, so far as conditions are similar.

More recent investigations, and reports received by the United States Department of Agriculture from farmers located throughout the cotton belt, show that a large part of the 1923 crop was produced at from 20 to 25 cents per lb. of lint, the average yield of the cotton belt for that year being 131 lb. of lint per acre.

Fundamental changes have taken place in the conditions of cotton production in the United States within recent years. The average cost of production has been adversely affected by several economic factors. The boll weevil has, in certain cases, reduced the average yield per acre by as much as 30 per cent. Growers have found industrial and urban occupations more profitable than cotton growing in the existing circumstances. Prices for commodities and labour are fully 100 per cent higher than before the war, while the restriction of immigration has also had an adverse effect on the labour supply for the cotton industry.

The chief methods resorted to in combating the boll weevil have been the spraying of the plants with an arsenical insecticide, and the free use of fertilisers to encourage early maturity, which together have increased the cost of production as much as 10 dollars per acre.

In 1922 the lowest cotton production costs obtained in Alabama at 17 cents per lb. of lint, and the highest in Georgia at 27 cents, but the average throughout the belt was probably about 22 cents.

During 1923, in Texas, which is one of the most favoured cotton-producing States, the cost of raising cotton on the farm increased to as much as 20 cents per lb., and cotton picking commenced at 1 dollar per 100 lb. of seed cotton as against 75 cents in the preceding year.

Investigations of the United States Department of

Agriculture show that the average cost of cotton production on 1471 farms, in 1924, was 18 cents per lb. of lint.

COTTON PRODUCTION BY STATES
(In 500-lb. Bales)

States.	Years.					
	1839.	1859.	1879.	1899.	1919.	1924-25.
Texas . . .	..	345,170	805,284	2,584,810	2,971,757	4,770,000
Mississippi . .	386,803	962,006	963,111	1,286,680	957,527	1,080,000
Arkansas . . .	12,057	293,914	608,256	705,928	869,350	1,100,000
Georgia . . .	326,785	561,472	814,441	1,232,684	1,681,907	1,000,000
N. Carolina . .	103,852	116,411	389,598	433,014	858,406	756,000
S. Carolina . .	123,421	282,730	522,548	843,725	1,476,645	750,000
Alabama . . .	234,278	791,964	699,654	1,093,697	718,163	990,000
Oklahoma . . .	..	..	..	72,012	1,006,242	1,450,000
Tennessee . .	55,403	237,171	330,621	235,008	306,974	330,000
Louisiana . .	305,111	622,190	508,569	699,521	306,791	480,000
Missouri . . .	242	32,950	20,318	25,732	63,808	146,000
Arizona . . .	..	..	..	15	59,351	100,000
California . .	..	..	..	..	46,418	71,000
Virginia . . .	6,989	10,182	19,595	10,332	24,887	30,000
Florida . . .	24,221	52,122	54,997	53,994	19,538	22,000
Kentucky . . .	1,383	..	1,367	1,371	2,967	..
Illinois . . .	402	1,186	..	..	..	..
Indian Terri- tory . . .	..	..	17,000	155,729	..	..
Others . . .	12	173	..	93	5,399	69,000
Total . . .	1,580,959	4,309,641	5,755,359	9,434,345	11,376,130	13,144,000

THE SEA ISLAND COTTON INDUSTRY

Sea Island cotton is notable for its long, silky fibre, which is in demand for the manufacture of fine fabrics and laces, and where great strength and durability are required, as in the production of motor-car tyres. It is stated to have been introduced into Georgia from the West Indies in 1786. The conditions along the sea coast of this State and South Carolina proved to be well adapted to its cultivation, and it was found that the long fibre could be readily separated from its smooth, black seed by the roller gin.

The Industry's Development. — Production rapidly increased ; in 1804 the crop amounted to 22,500 400-lb. bales. Cultivation was restricted for many years to the islands and low coast lands of Georgia and South Carolina, but it was later taken up in Florida. In 1854, fifty years later, the

total production of the three States mentioned was 32,500 bales. Production continued to increase until 1905, when the record crop of 123,364 400-lb. bales was produced.

Cultivation was of a very intensive character in the Sea Islands. High ridges, from 4 to 6 feet apart, were thrown up with the hoe. In order to produce a high standard of cotton, the land was heavily fertilised with marsh mud, and the most careful methods of seed selection were practised. Prior to the Civil War, South Carolina cotton farmers were prosperous and independent; they owned slaves and grew a fine grade of Sea Island cotton, which found a ready market at remunerative prices. Most of the crop was shipped to factors in Charleston, who sold it on commission and, in some instances, even acted as the farmers' bankers. The negroes did not desert the plantations after the war, so except that free labour was substituted for slave labour, little change took place.

Up to 1889, American markets, of which Charleston and Savannah were the principal, set the price for extra long staple cotton, for negligible amounts of Egyptian cotton were then imported. With increased production in Georgia, and also in Egypt, these markets lost their prestige, and were no longer able to fix the price for this class of cotton, and prices declined. Production costs increased and involved many farmers in debt to the factors to such an extent that 80 per cent of the Carolina Sea Island crop was raised on money advanced by them.

In Georgia and Florida similar conditions obtained as regards Sea Island cotton production; as in South Carolina negro labour was principally employed. For many years Florida was the principal producing State, then Georgia took the lead and produced as much as Carolina and Georgia combined. In 1918 Georgia and Florida each produced about 21,000 bales, while South Carolina produced only half this amount.

"Fancy Sea Island", which is produced on the islands and mainland along the coast of South Carolina, has a fibre of 2 inches or even more in length, and surpasses all other types of cotton in length, strength, and fineness. But the bulk of the crop, which is commonly known as "Floridas" and "Georgias", has a staple of $1\frac{1}{2}$ to $1\frac{3}{4}$ inch. The high

quality of Sea Island cotton is primarily due to the careful seed selection that has so long been practised in the Carolina Sea Islands, and it is to quality more than to quantity that economic importance attaches to the industry.

The Industry's Decay.—It was the custom for Georgia and Florida growers to renew their planting seed at least once in three years with fresh Carolina stock. Selected Carolina seed was introduced to the West Indies in 1902, and expert Carolina growers were hired to teach the West Indians how to produce the crop for market. Success attended these efforts, and within a few years the Carolina farmers began to suffer from West Indian competition; they determined to abstain from selling their seed, not only to the West Indies but to Georgia and Florida farmers and their fellow-islanders as well. As a result much inferior seed was planted, and, in addition, seed of Upland varieties. Cross-fertilisation took place in the fields and general deterioration through hybridisation was the natural corollary.

As a short crop was anticipated in 1912, growers and small dealers decided to hold their stocks for higher prices. Spinners, on the other hand, considered that their margin of profit was already sufficiently narrow, and buyers were unable to procure cotton at the price that spinners were willing to pay. A deadlock developed in the market until the following spring. Meanwhile spinners had been experimenting with Sakellaridis, a new variety of Egyptian cotton, and they turned their attention to this and to brown Egyptian for their immediate requirements, and also for those of a year ahead.

Sakellaridis cotton came to be substituted for Sea Island cotton, because it was found to have a comparatively uniform staple of $1\frac{1}{2}$ inch in length. Although harsher and less elastic than a good quality of Georgia, it possessed quite as much strength and more closely resembled Sea Island than most Egyptian varieties; further, that it could be manufactured with less waste, worked better in the card-room, made stronger yarn and cloth, and, having once introduced it, the trade experienced difficulty in reverting to Sea Island cotton.

Another factor that adversely affected the Sea Island cotton industry was the question of economy, which was

responsible for a scaling down in the length of staple employed in the fine goods trade. Demand for low-priced goods, coupled with keen competition, compelled mill owners to accept low-priced orders. Improved cotton-mill machinery enabled manufacturers to use shorter staples in their products, and still render them sufficiently attractive to procure purchasers. The motor-car tyre industry furnishes an excellent example of this tendency. Originally the best grades of Sea Island cotton were not considered too good for tyre manufacture. Competition and price cutting encouraged the use of the lowest grades of Sea Island and Egyptian, as well as long staple Upland cotton. This trend of affairs seriously menaced the very existence of the Sea Island cotton industry, and it was still further menaced by the ravages of the boll weevil, for, as the Sea Island cotton plant requires a long growing season and matures late in the autumn, it is especially susceptible to damage by this pest. Before its advent, the average production of Sea Island cotton was about 90,000 bales, of which about one-tenth was fancy grades. Subsequently production rapidly declined, and during recent years the crop has been a failure; the crop for 1920 only amounted to 2000 bales.

Handling the Crop.—Sea Island cotton is all ginned by roller gins, for saw gins cut and damage the long fibres. Compared with saw gins, roller gins have a much lower output, and are therefore more expensive to operate. South Carolina cotton is put up in bags $7\frac{1}{2}$ feet long by $2\frac{1}{2}$ feet in diameter, which contain 300 to 400 lb. of lint. They are filled by hand and are pressed in a hand-screw press. The lint is not compressed for export. The use of this bag is confined to the Sea Islands, and it serves as a trade mark to distinguish the crop. The cotton is marketed at Charleston, and the finest cotton is grown by a small number of farmers who have practised careful seed selection for many years. Their cotton is not only long and fine, but it is packed with great care as regards cleanliness and uniformity. The comparatively high prices secured for ordinary Carolina Sea Island cotton is likewise largely due to careful preparation, for all stained and weak cotton and bits of leaf are removed before it is baled.

Sea Island cotton produced in the interior is packed into

bales of 400 lb. weight by steam press ; these bales have the same size and shape as Upland cotton bales, but they are covered with heavy burlap, and are sewed up with strong cord in place of the steel ties used for securing Upland cotton bales. The interior crop is marketed at Savannah, Blackshear, and Valdosta in Georgia, and at Alachua and Madison in Florida.

The Cultivation of Sea Island Cotton.—The character of the Sea Island cotton plant has been radically changed since its original introduction ; for several generations planters have selected seed from the most compact, earliest, and most productive plants with the longest and finest staple.

Atmospheric humidity appears to be an essential factor in the production of high-grade lint. Fields exposed to the moisture-laden ocean breezes produce a finer and more glossy staple ; it is for this reason that a wet season is more favourable for Sea Island than for Upland cotton. In the absence of sufficient atmospheric moisture, harsh and shorter staple is produced.

Although a liberal and regular water supply is needed for favourable plant growth, thorough drainage is essential. A sandy or sandy-loam soil, with a compact, clayey subsoil about a foot below the surface, are the ideal soil requirements. In the Sea Islands, where a clay subsoil rarely occurs, the subsoil is rendered more compact by the trampling of stock when the land is fallow. Too rank growth is encouraged if the soil is rich in humus, but a shortage of this material induces Rust and boll shedding and restricts growth.

In the Sea Islands and in parts of Florida it is customary to plant cotton alternately on half of the farm, and to leave the other half to become covered with weeds, on which stock and sheep are pastured. This practice has its value for soil recuperative purposes, and for checking plant diseases and insect pests, but it cannot be defended on the principle of land economy.

Drainage is provided for by open ditches, plank drains, and tile drains. The custom of planting the cotton on ridges or beds, raised from $1\frac{1}{2}$ to 2 feet above the surface, serves a useful purpose in this connection. These ridges are usually 5 feet apart.

The preparation of the land for planting commences in

January. The old cotton plants are broken down and burned along with any other coarse litter, in the furrows. In the following month, cotton seed is spread between the ridges, at the rate of 1000 lb. per acre, together with a mixture of stable manure, pine straw, marsh grass, and similar material. This mixture is covered with soil by turning a furrow from each side with a plough. About a month later, commercial fertiliser is drilled in at the rate of from 600 to 1000 lb. per acre.

The following are typical examples of home mixed fertilisers, and quantities applied per acre, in the Sea Islands :

(1) 200 lb. kainit, 200 lb. acid phosphate, 200 lb. lime, and 1000 lb. cotton seed.

(2) 200 lb. each of kainit and acid phosphate, 400 lb. cotton seed meal, 25 bushels cotton seed, and 25 loads marsh mud.

(3) 300 lb. each of kainit, acid phosphate, and cotton seed meal.

In Georgia and Florida smaller quantities of fertiliser are used. A complete fertiliser, containing 2 per cent of ammonia, 8 per cent of phosphoric acid, and 2 per cent of potash, is in common use, and it is applied at the rate of from 100 to 250 lb. per acre.

Before planting, the ridges are rolled with a double roller, which rolls two ridges at once ; on the rollers are strips of wood fixed from 12 to 18 inches apart, which mark the position of the stands for planting. Planting is generally done by hand, but mechanical planters are sometimes used. It may begin after the 20th of March, although the first ten days of April is preferred.

When the young plants are well above the ground, cultivation begins with a sweep and is then hoed by hand. Thinning out begins when the plants are 5 or 6 inches high, and is continued gradually until only one plant is left to a stand or hill. Cultivation and hoeing alternately is done weekly—eight to ten times in all—until July or August ; by this time the plants are 4 or 5 feet high, and are too large for cultivation to be continued without injuring them. At this period the plants are growing on broad beds separated by furrows about a foot deep.

In Georgia and Florida level cultivation is practised.

Cotton picking starts at the end of August or early in September. The best Sea Island cotton has a natural bloom or lustre, which greatly enhances its appearance, and is essential for certain kinds of fabrics. Cotton which has been left on the plants after it is mature, and exposed to adverse climatic conditions, loses its bloom and assumes a grey, lifeless appearance. Loss of bloom is also generally associated with a weakened staple. Similar effects are produced by picking the cotton when it is wet with dew or rain, and storing it in this condition without first drying it in the sun. In the Sea Islands, the fields are usually picked over every ten days, and as little trash as possible is picked with it. Each picker sorts his own picking and discards discoloured locks, pieces of leaves and bolls, and other trash. The cotton is then spread out in the sun to dry on a wooden platform and is turned frequently. It is considered that this procedure, in addition to drying the cotton, causes the lint to absorb some of the natural oil from the seed, which increases its lustre. Afterwards it is again sorted for discoloured locks and trash. Dirty cotton is whipped over a coarse wire screen to remove the sand. It is then stored in bulk for from four to six weeks before being ginned.

Foreign matter, discoloured lint, and motes are sought for, and picked out, both as the cotton enters and leaves the gin.

Reference has already been made to the careful seed selection methods practised in the Sea Islands. The basis of the selection is the choosing of the best individual plant in the field and the preservation of its progeny. Superior plants are marked and carefully compared in the field, and the seed cotton from each is picked and kept separate and minutely examined. The seeds from the best plant are planted separately. Should the plants raised from them produce the qualities of the parent, the seed is again planted separately. Sufficient seed is usually obtained to plant about 5 acres in the third year, while in the fourth year sufficient seed is raised to plant the whole crop. As a plant is selected in this manner each year, a new stock of seed is constantly available. Long and patient work, involving much care and skill, is requisite to evolve a fine strain of cotton, and certain breeders refuse to part with their seed even to their neighbours.

In the absence of supplies of selected seed from the Sea

Islands, interior cotton growers have devoted more attention to seed selection, and some farmers in Georgia and Florida have by this means maintained the standard of their cotton for fifteen and more years.

Different farmers have different ideas as to the best form of plant and the most profitable type of staple. This has naturally encouraged the development of a number of distinct varieties, which vary greatly with regard to the length and strength of staple, form of the plant, percentage of lint to seed cotton, size and appearance of the seeds, and other characters. Certain farmers specialise in a variety with a staple of medium length because of its superior productiveness, while others favour a variety with an extra long and fine staple. There appears to be a fairly uniform demand for a few hundred bags of extra fine cotton with a staple of 2 inches and over, and for which a high price is paid, but more than this is difficult of sale profitably. There is, however, a liberal demand for the medium grades with a staple of $1\frac{5}{8}$ to $1\frac{7}{8}$ inch in length.

Ideal qualities sought for in the selection of Sea Island cotton, briefly stated, are: A compact, productive, early maturing, disease-resistant plant, 4 to 6 feet high, with a strong main stem, and from two to four well-fruited basal branches, the joints of all branches close together, bearing a boll at each joint. Bolls four-locked, large, long but not tapering too abruptly, well filled to the end, and opening wide. Seeds small, black, well filled, and with a small green tuft at the end. Staple long, fine, strong, lustrous, creamy tinted, and uniform.

Meade Cotton.—In an effort to preserve the industry, the Department of Agriculture endeavoured to develop earlier strains of Sea Island cotton that would yield profitable crops in the presence of the boll weevil, but in this connection no practical results have been attained. More success has attended their efforts to substitute an early-maturing Upland variety known as Meade, which, under favourable conditions, produces lint with a staple of $1\frac{1}{8}$ in. in length, of fine texture and quality, and closely resembling Sea Island cotton. Moreover, as the Meade cotton has smooth seeds, it can be handled in the roller gins used for Sea Island cotton, except that a new seed-grid has been designed and adjusted to the

roller gins used for Sea Island cotton, so as to deal with the Meade seeds, which are larger than those of Sea Island cotton.

Meade cotton originated from a selection made in 1912, in a field of Black Rattler cotton in Texas. Later selections from the progeny of the original selection have resulted in further improvements. During five years that the improved stock was grown in the south-eastern States, it yielded about twice as much as Sea Island cotton, and not less than the short stapled Upland varieties that were grown under similar conditions. Given the same care in regard to harvesting and ginning as that bestowed on Sea Island cotton, the Meade cotton is said to be readily accepted on the market on a par with Sea Island, which it resembles so closely as to be indistinguishable except by experts. Owing to its early maturity and high yield, it has been found possible to cultivate this cotton profitably even in the presence of the boll weevil. Comparative experiments have shown that Meade cotton is as early and prolific as the short staple varieties that are grown in the south Atlantic coast districts.

With the object of producing and maintaining a sufficient supply of pure Meade seed, farmers have been encouraged to organise on a community basis, for the purpose of growing Meade cotton only, also to maintain the high standard of the variety by continued selection and carefully controlled ginning. It is well recognised that such organisations are able to market their crops more directly in large quantities of uniform quality, and thus secure more remunerative prices.

The urgency of isolating Meade cotton from contamination with short staple Upland cotton requires to be emphasised, for Upland hybrids can be readily recognised in Sea Island cotton, whereas such hybrids in Meade cotton are difficult to distinguish because of their similarity.

The percentage of waste in spinning Meade cotton is somewhat higher than with Sea Island cotton, but it is considered that this wastage may be reduced, or even obviated altogether, by changes in the adjustment of the machinery for the regular spinning of Meade cotton. As regards the spinning and manufacturing of Meade cotton, comparative

tests of Meade, Sea Island, and Egyptian cotton have shown that the difference between these fibres is so little as to be practically negligible.

Cotton Production under Irrigation. Experiments were first conducted with cotton production in the irrigated valleys of Arizona and southern California in 1905, and within seven years the crop was well established in several places. As early as 1909, commercial quantities of Upland cotton were produced, while the first commercial quantity of Egyptian cotton was produced in 1912. Since the latter date the area under cotton has been largely extended. It is estimated that, including some 30,000 acres of Upland cotton in the Pecos and Rio Grande Valleys in Texas and New Mexico, and about 125,000 acres in Lower California, there were half a million acres devoted to cotton production in the south-west in 1920. About one half of this area was planted with a variety of Egyptian cotton known as Pima, which has a staple of $1\frac{1}{2}$ to $1\frac{5}{8}$ inch in length, and 100,000 bales of this cotton were produced in that year.

Originally, fairly pure stocks of the Upland varieties Triumph and Durango obtained, but latterly these have become so intermixed, and contaminated in addition with other varieties, that there is little or no pure seed of Upland cotton in the south-west. Since 1917 there have been ample supplies of pure Pima seed available, for special care has been exercised to avoid varietal mixture both in the field and in the gins. All the Pima seed has been raised from a single plant selected in 1911.

It has been found that although Pima and Upland varieties produce approximately the same quantity of seed cotton per acre (in 1920 it was estimated at 1000 lb. per acre), the Upland varieties produce about 30 per cent more lint per acre owing to their higher lint percentage to seed cotton. The ginning percentage of lint to seed cotton is 25 and 33 for Pima and Upland respectively. Owing to the superior quality of Pima lint, it realises about double the price of Upland lint. Production costs for both kinds are about equal, but Pima costs nearly twice as much to harvest as Upland; cotton pickers gather 60 to 100 lb. of Pima, and from 125 to 175 lb. of Upland, seed cotton per day.

The approximate selling price for Pima cotton in the Salt River Valley from 1912 to 1919 was as follows :

Year.	Cents.	Year.	Cents.
1912 . . .	21	1916 . . .	42
1913 . . .	18.5	1917 . . .	80
1914 . . .	15.5	1918 . . .	55
1915 . . .	22	1919 . . .	85

In 1920 the price advanced rapidly during the season from 60 cents to \$1.25.

The Pima Egyptian cotton is roller ginned and the Upland cotton is saw ginned. In 1920 there were 548 roller gins operating in the south-west. The capacity of these gins is $1\frac{1}{2}$ to 2 500-lb. bales per day, if they are run continuously with two shifts of men. A stand of ten gins, with self-feeders, can be operated with eight or nine men. In the Salt River Valley there were 390 roller gins in operation in 1920, which proved inadequate to keep pace with the quantity of cotton being picked at the height of the season, when it is estimated that 30,000 pickers were harvesting 1000 tons of seed cotton per day.

Pima cotton is sampled at the ginnery before it is baled ; usually it is not compressed at primary shipping points. The Upland crop has generally been compressed at the primary points ; it is sampled at the ginnery or at the compress, each bale being slashed on both sides for the sample.

It soon became evident that sufficient labour was not available locally to meet the increasing requirements of the cotton industry. In 1916 this problem was solved in a novel manner in the Salt River Valley. The gin owners were induced to sign an agreement binding them to increase ginning charges by \$2.00 per bale above the regular charge, and to refund the money thus collected to the labour organisation, for the purpose of providing a fund for procuring labour from Mexico and elsewhere. The signed agreements supply the necessary security for the labour organisation management to borrow money from the bank for its operations early in the season. Special dispensation from the Federal immigration authorities had to be obtained to import Mexican labour, and, as it was found desirable to bring in families, medical care, shelter for living, and schools for the

children had to be provided by the organisation. Sufficient labour has been procured to prevent labour costs increasing unduly, and, so far as it is possible to judge, the scheme has proved satisfactory.

The production costs for Pima and Upland cotton, with the exception of possibly lower land rental for the latter, are approximately the same. The estimated costs of producing Pima cotton in the Salt River Valley in 1920 were as follows :

1. Fixed charges :	\$	
Land rental or interest and taxes.	35-00	
Use of machinery and equipment.	3-75	
Irrigation water	5-00	
		\$43-75
2. Growing cost :		
Cultural operations and seed	30-50	
Supervision	5-00	
		35-50
Total cost per acre		\$79-25

The estimated harvesting cost for Pima and Upland in 1920 is given below :

Harvesting cost, per 100 lb. of seed cotton :

	Pima.	Upland.
	\$	\$
Picking	4-00	2-00
Hauling to gin	0-25	0-25
Ginning	1-20	0-50
Yardage, Insurance, Association fees	0-35	0-35
Picking supervision, tents, etc.	0-15	0-15
Total	5-95	3-25

Irrigation water has been provided in certain cases by damming rivers, while in others it is pumped from underground supplies. Water for the Salt River Irrigation Scheme is stored by the Roosevelt Dam. This is one of the most colossal and most successful schemes of this nature in existence. The total cost of the dam exceeded 12 million dollars, and it took five years to build. This dam is situated some 80 miles from Phoenix, Arizona, where it closes a narrow mountain canyon and creates a lake 25 miles long and from 1 to 1½ mile wide, with a total volume of 1,367,305 acre-feet

of water. It stores the waters of the Salt River and Tonto Creek, and allows them to return in proper quantities through sluice gates to the river bed, where it flows on and collects the waters of the Verde River. At the Granite Reef diversion dam the water of the three streams is turned into canals. There are 781 miles of main canals and laterals, while the length of a power canal at the dam is 19 miles. The area of the drainage basin is 7500 miles. The area of the land under irrigation exceeds 200,000 acres. The average quantity of water used is $3\frac{1}{2}$ acre-feet.

The Yuma Reclamation Project embraces an area of more than 100,000 acres, situated in the States of Arizona and California. Water has been provided by damming the Colorado River. In order to protect the valley lands from flood damage, an extensive system of levees, with a combined length of 70 miles, has been erected. Water is diverted from the Colorado River, at the Laguna Dam, into the principal canal on the California side of the river. By this canal water is taken to the Bard and Indian Reservation, and is also conveyed through $13\frac{1}{2}$ miles of canal, where it is conducted under the Colorado River at Yuma, by means of an inverted syphon, to canals which supply the Yuma Valley and Yuma Mesa. The Laguna Dam is a diversion structure of the Indian weir type and is not a storage reservoir. It is nearly 5000 feet long, and raises the level of the water 19 feet above the old river bed. A striking feature of this diversion system is the desilting arrangement, by which 25 per cent of the silt is eliminated from the water as it is diverted at the end of the dam. Only the surface water is allowed to pass into the main canal, so that the heavy sands and a variable quantity of silt are left behind in the settling basin. The inverted syphon consists of circular concrete shafts connected with a circular concrete-lined tunnel, 930 feet long and 14 feet in diameter. Government levy on farmers a construction charge of \$75 per acre, which is payable within twenty years, free of interest. Two acre-feet is the minimum annual amount of water that a farmer can take, and this is charged for at the rate of \$1.75 per acre-foot. Any additional water needed is charged for at the rate of \$2 per acre-foot. In 1920 the average amount of water used for cotton cultivation was 3 acre-feet. The United States Reclamation Service has fixed the charge for building

the Salt River Irrigation Project at \$56 per acre. Payment is to be made as follows: 2 per cent of the \$56 each year for four years, 4 per cent each year for two years, and 6 per cent each year for fourteen years. In 1920 the cost of irrigation water, including the upkeep and improvement of canals, was \$1.60 for the first two acre-feet and \$0.80 for the third acre-foot. Three acre-feet is the average amount of water required for irrigation in the Salt River Valley.

In the San Joaquin Valley, cotton is grown with irrigation water pumped from underground supplies; in 1920 water for this purpose cost \$7.18 per acre, and cotton land was irrigated six or seven times during the season.

Irrigated Cotton Cultivation.—Of the half million acres devoted to cotton cultivation in the irrigated south-west, about equal areas were until recently in Pima-Egyptian, and Upland cotton. Only 5000 bales of Pima cotton were produced in 1924, but the crop of this cotton in 1925 is estimated at 25,000 bales. Latterly Acala has been largely planted in place of Pima-Egyptian in both Arizona and California, and to a less extent in Texas. When grown under favourable conditions, Acala cotton has a staple of $1\frac{3}{8}$ inch. In certain sections it is only possible to grow Upland cotton, owing to the high altitude, or to the short growing season. Pima cotton requires a frostless growing season of from 275 to 300 days, whereas Upland cotton may be grown in 225 days between frosts. In the Pecos, and Rio Grande Valleys, and in the Imperial Valley, Mexico, only Upland cotton is grown; formerly Pima only was grown in the Salt River Valley, while both kinds were grown in the Yuma, Imperial (California), Coachella, and San Joaquin Valleys. In these valleys, during the growing season, the weather is hot and arid, similar to that of Egypt, and the best farmers obtain yields of Pima superior even to those obtained in Egypt. The territory in the United States where Pima cotton can be profitably grown is limited to these hot, irrigated valleys of the south-west.

Climatic vagaries detrimental to cotton production in these regions comprise cold weather in the early spring, rain that causes a crust to form on the ground after the seed is planted, hail and wind in the growing season, excessive heat during the flowering period, and early autumn frosts.

The characteristic features of cotton cultivation under irrigation are : the thorough preparation of the land, including careful levelling to admit of the whole field being uniformly irrigated, late thinning out of seedlings, growing the plants close together in the rows, restricting the use of irrigation water until the plants begin to flower, and frequent light irrigations after flowering commences until the crop is mature.

The ideal type of soil is a medium sandy loam, which is easy to work and absorbs water readily ; but good results have been obtained on both heavy and sandy soils. Alkaline and hard-pan soils are not suitable, although cotton will thrive with a small amount of alkali in the soil. It is generally found that soils which produce good crops of lucerne and similarly deep-rooted crops, grow good crops of cotton.

Land levelling is an important consideration to ensure uniform irrigation. Land which is nearly level requires less water for the crop, the water is more easily controlled, and more even irrigation can be effected than on land with a heavy slope. The best gradient is largely determined by the character of the soil, for a steeper gradient may be given to light porous soils, into which water readily sinks, than to heavy soils which do not become saturated unless irrigation water remains standing for some time. Imperfect levelling causes the irregular germination of seed ; in certain areas, plants become stunted through drought, while in others excessive moisture encourages too luxuriant growth and late boll development.

It is considered preferable to commence preparing the land in the autumn or early in the winter, so as to have it in good condition for planting by the early spring. Land which has been just previously under lucerne, or has become densely overgrown with weeds, is ploughed up 2 or 3 inches deep in the autumn so as to expose the roots to the sun, and is then cross-ploughed to a depth of 6 or 7 inches in the spring. When cotton follows cotton, the old plants are cut down with a stalk-cutter as soon as the crop is harvested, and the land is then ploughed 6 or 7 inches deep to bury all the plant material.

A thorough irrigation is essential just before planting time, to prepare a moist seed bed, and to store up as much

water as possible for the crop's summer requirements. In order to provide a well-pulverised seed bed, the land is first cultivated with a disc or spring tooth harrow, followed by a drag or smoothing harrow.

Planting takes place as soon afterwards as it is practicable, to ensure the seed being deposited in well-moistened soil, but not before the danger of late spring frost is passed, which is usually early in April. Early planting is advisable, not only because it is necessary to take advantage of the longer growing season, but because young plants exhibit more normal branching and fruiting habits if they are not subjected to very hot weather in the early stages of their growth.

Planting is done with a 1-row or 2-row planter, using 30 or 40 lb. of seed per acre, in rows about 4 feet apart; on poor land 3 to 3½ feet apart for the rows is considered sufficient. Level planting is preferred, except on heavy soils; on these, ridges are thrown up with a lister. From 1 to 2 inches is sufficiently deep to plant the seed. When seed is planted deeper than 2 inches, it is found that many of the young seedlings are unable to push their way through to the surface. The use of a lister attachment to the ordinary planter shoe is recommended, as this pushes away the dry surface soil and causes the seed to be deposited in the moist soil below. It is not desirable to irrigate immediately after planting, as this causes a crust to form on the surface, which it is difficult for the young seedlings to break through.

Shallow cultivation commences as soon as the young plants are well above the ground; this is to break up any soil crust that may have formed, to check evaporation, and to destroy weeds. For this purpose drag or spike tooth harrows or disc cultivators are used. For later cultivation, small shovels and sweeps are preferable, as these destroy more weeds and leave the soil in better condition for irrigation and subsequent cultivation. Deep cultivation causes the soil to dry out too rapidly and damages surface roots. Frequent shallow cultivation, at regular intervals, during the early stages of plant growth, keeps weeds in check, aerates the soil, encourages root development, and conserves soil moisture. As the plants develop, the soil is gradually worked towards them at each cultivation, until

a ridge is formed 3 or 4 inches high and 12 to 14 inches wide. This serves to support the cotton plants and makes irrigation more easy of control. Cultivation is practised after each irrigation, until the plants are too large for this to be conducted with safety.

The young plants are generally thinned out after the second irrigation, when they are 10 or 12 inches high, leaving them from 10 to 14 inches apart in the rows. Thinning is purposely delayed until this stage, so as to suppress the basal vegetative branches and encourage the development of the fruiting branches.

Generally it is not necessary to irrigate for several weeks after planting, and when the plants are several inches high, but the precise date is determined by local soil and climatic conditions. The second irrigation follows after three or four weeks. Once the plants have become well established, it is desirable to withhold water so long as they do not become actually stunted. While the plants are growing vigorously, irrigation is not required, nor is a slight wilting of the leaves, during the hot hours of the day, necessarily an indication of lack of root moisture. Over-irrigation induces rank vegetative growth at the expense of fruitfulness. Ordinarily two irrigations are sufficient until early in July, when the plants begin to flower. From this date, until early in September, irrigation is necessary every 10 or 15 days; during this period the plants should not be permitted to wilt, or boll development is affected. After the beginning of September, irrigation water is more sparingly applied, only sufficient being required to keep the plants in a healthy condition. After the first lot of cotton is picked, one or two more irrigations usually suffice.

Picking commences in the latter half of September, and is generally done at least three times. Pima cotton bolls are smaller and do not open so wide as Upland bolls, so that the pickers gather a smaller quantity of the former kind in a day. Good pickers pick on an average 125 lb. of Pima seed cotton in a day, but beginners only pick 50 or 60 lb.

In some Californian fruit-growing districts, it has been found that cotton may be profitably cultivated between the rows of young fruit-trees, and thus provide a profitable crop for the farmer, while he is waiting for his fruit trees to come

into bearing. In some cases, where two rows of cotton were grown between two rows of young vines, a crop of nearly a bale of lint per acre has been obtained. The vines were not injuriously affected, while the quality of the cotton compared favourably with that grown in the ordinary way.

SUPPLY AND DISTRIBUTION OF AMERICAN COTTON (LINTERS EXCLUDED)

(Compiled by the Merchants' National Bank of Boston)

Running Bales; 000's omitted

	1920-21.	1921-22.	1922-23.	1923-24.	1924-25.	1925-26.
Supply :						
Carry-over Aug. 1 . .	6,402	9,944	5,671	3,370	2,754	3,590
Ginnings after Aug. 1	13,271	7,978	9,714	10,106	13,617	..
Ginnings in July . .	..	15	64	22	159	..
City crop, etc. . .	333	222	309	182	202	..
Total . .	20,006	18,159	15,758	13,680	16,732	..
Distribution :						
Consumption . .	10,062	12,488	12,388	10,926	13,142	..
Carry-over July 31 .	9,944	5,671	3,370	2,754	3,590	..
Total . .	20,006	18,159	15,758	13,680	16,732	..

CHAPTER IV

COTTON PRODUCTION IN INDIA

General agricultural conditions—Cotton manufacture—Land tenure—The co-operative movement—Long *v.* short staple cotton—Indian cottons—Efforts to improve Indian cottons. Bombay: climate, soils, varieties of cotton grown, cultivation, cotton picking. Central Provinces and Berar: climate and soil, varieties of cotton grown, cultivation, seed distribution. Hyderabad: varieties of cotton grown. Madras: cotton areas, climate and soil, varieties of cotton grown, cultivation, seed distribution. Punjab: varieties of cotton grown, cultivation, auctions, seed distribution, possible extension of irrigated cotton—The British Cotton Growing Association's Estate: cotton yields, cultural methods, buying agency, progress in cotton production. Central India. United Provinces: varieties of cotton grown, irrigation and cultivation, markets. The North-West Frontier Province. Sind: varieties of cotton grown, cultivation and irrigation. Burma: varieties of cotton grown. Bihar and Orissa. Bengal. Assam. Baroda. Rajputana. Mysore. Crop forecasts—Cotton picking—Marketing the crop—Ginneries — Adulteration — Central Cotton Committee — Summary and statistics.

WITH the exception of the north-east, cotton is produced in most parts of India, but it is chiefly grown in the western half of the country. The area under cotton cultivation is only about one-third less than that in the United States of America, yet, owing to the low yields that are obtained, the crop is only one-third as large as the United States crop. During the period 1912-13 to 1921-22 the average area under cotton was 22,071,000 acres; the average crop was 4,499,000 bales of 400 lb., while the average yield per acre was only 81·5 lb. of lint, as compared with a yield of 169·8 lb. of lint per acre in the United States for the same period. The season 1919-20 saw the largest Indian cotton crop yet produced; it amounted to 5,796,000 bales, which was grown on 23,352,000 acres, an average yield of 98·8 lb. per acre. The crop for the seasons 1922-23 and 1923-24 was approximately 5,075,000 bales and 5,042,000 bales respectively.

The cultivation of cotton is not intensive as compared with that of such crops as wheat. Cattle manure is scarce, and it is seldom applied to cotton, as it is required for more profitable crops. The best cultivation obtains in Gujarat, the Central Provinces and Berar, and parts of Madras. Over the bulk of the cotton-growing regions, especially in Berar, Central India, Bombay, Baroda, Madras, and Hyderabad, the area under cotton often reaches as much as 50 per cent of the total cropped area, which indicates the need for a longer rotation and serves to explain the poor yields.

General Agricultural Conditions.—The outstanding feature of Indian agriculture is that it provides employment directly or indirectly for such a vast majority of the population. The annual value of India's agricultural produce is estimated at £1,683,000,000, and 240,000,000 people depend for their livelihood on agriculture or its subsidiary industries, out of a total population of 320,000,000. In fact the whole outlook is agricultural. The condition of the crops is the all-absorbing topic of conversation, for it is to the harvest that the Government looks for its revenue, the labourers and artisans for their wages, the landlord for his rent, and the grain merchant for his profits. Indian land revenue produces more than 23 per cent of the whole income of the State and about 39 per cent of the revenue proper.

Of the rural population, probably nine-tenths live directly or indirectly by agriculture. Agricultural labourers predominate in the landless class, which is considerably increasing, although there is ample land in India for all the rural people. Hitherto comparatively little relief has been afforded by migration, either to congested or sparsely populated districts.

There are two principal harvests, the *kharif* (autumn) and the *rabi* (spring). The agricultural year may be broadly divided into four seasons: (1) the period of the south-west monsoon—June to October; (2) the period of the retreating south-west monsoon, or what is popularly known as the north-east monsoon—November and December; (3) the cold weather period—January and February; and (4) the hot weather period—March to May. The greatest part of India's rainfall is supplied by the south-west monsoon, and the prosperity of the peasant is largely dependent upon this

rainfall being normal in quantity and seasonably distributed. The autumn crops are sown with the first rains of the south-west monsoon, and they are reaped between September and December. The spring crops require less rain; they are sown in October and November, and are harvested in March and April.

As in other countries, there are good and bad farmers. The best cultivation compares favourably with that of the average British farmer, while the worst is mainly brought about by the lack of facilities for improvement. The principles of manuring, rotation, and thorough tillage are duly appreciated and practised, and the land is twice cropped each year under well irrigation in Bombay, Madras, and generally throughout peninsular India. In the plains, where the climatic conditions are exceptionally trying at certain seasons of the year, the diligence of the ordinary farmer is most extraordinary. Conditions are still such that the village, and even the family, is to a very large extent a self-supporting unit. The farmer sells his cotton crop to the village shopkeeper or small middleman, who mixes all seed cotton after purchase. So long as this practice obtains, the farmer is unlikely to derive much benefit by cultivating better quality cotton than that generally grown in the district.

Cotton Manufacture.—India's cotton mills, some 300 in number, are mainly found on the west coast; they operate about 8 million spindles, and have an annual output of 700 million lb. of yarn spun from Indian cotton. About one-half of this amount is used by the mills, some 57 million lb. are exported to China and other places, and the balance is consumed by hand weavers. In addition, 60 million lb. of yarn are annually imported from the United Kingdom and Japan for the use of hand weavers. Such are the conditions prevailing in India, that, notwithstanding the progress of machinery, approximately 2 million hand looms are distributed throughout the country. Indeed the hand-loom industry continues to make steady progress, and is the largest of India's "cottage industries". The numbers of men, women, and children engaged in it are estimated at 8 millions, who produce one-quarter of the cotton requirements of the country, *i.e.* about 1000 million yards. Nevertheless, India

still continues to purchase Lancashire cloth to the value of £40,000,000 annually; but as prices have doubled, it follows that only one-half as much cloth is imported as hitherto. Japanese cotton goods compete favourably with those of the United Kingdom and the Continent; for certain classes of cotton hosiery Japanese manufacturers control the market.

Land Tenure.—In certain parts of the country the land is owned by large proprietors, and in others by numerous peasant occupants subject to no private landlord. The holding of the peasant occupant or the tenant is by no means large, and in some districts it is excessively small. Farming on a large scale is quite exceptional. Even where the proprietary unit is of vast dimensions, as in parts of Oudh and lower Bengal, the greater part of the property is held on lease by a large number of small tenants.

Agricultural holdings vary in size in different parts of the country, in accordance with the character of the soil, facilities for cultivation, and similar considerations. In Madras, the average area of cultivated land held by occupants direct from Government does not exceed 8 cultivated acres. In the Punjab, the average size of the cultivating unit, whether under tenants or proprietors, is 3 acres. In the thickly populated parts of Bihar, the tenant's holding averages less than half an acre.

The rights of many of the holders are subject to devolution by inheritance, and the customs which regulate inheritance are generally such as to encourage constant land subdivision. Obviously, unchecked, this system of subdivision, if proceeded with long enough, must ultimately lead to a unit of cultivation totally inadequate to support the family. Joint cultivation is already practised to a considerable extent.

Owing to the enormous increase in the population of India, the greater demand for land has forced up the price of it to such an extent that the entire produce scarcely more than suffices to pay the price demanded. The conditions are totally different from those in such sparsely settled countries as Australia and Canada, where a system of bulk production obtains, and the farmer produces only one crop on extensive areas. India is densely populated with small farmers, who cultivate only a small area, and whose first endeavour is to produce food to feed the family and cattle.

Under native rule the cultivator dealt direct with the representative of the State, and the whole of the economic rent passed straight from one to the other. At first the Government continued the native custom of taking as land revenue the whole, or nearly the whole, of the economic rent. The Government dealt direct with the cultivator when the intermediaries were few or weak, and this practice still obtains in what are known as the *ryotwari* (tenant) areas, which comprise Assam, Bombay, Burma, and the larger portion of Madras. Where the intermediaries were numerous and powerful, as in the *zamindari* (landowner) areas of Bengal and the United Provinces, the Government dealt with them, and they collected the rent from the cultivators, and, when paying in the proceeds to the Government, were permitted to retain about 10 per cent for their own use. The payments now representing the net rental have developed from this percentage. The incidence of Indian rents is peculiar, for in most countries the land revenue is an assignment from the rent made by landowners to the Government, whereas in India the net rent is, historically speaking, a relinquishment of part of the profits of land by the Government to the landowners. In spite of the diversity of systems that obtain, one feature is common to all, viz. : the recognition of the State as part proprietor in the land, and the payment of the tax is a practical demonstration of that recognition.

With the increase of population, and its concomitant the greater competition of tenants for land, the necessity arose for a system prescribed by law for the guidance of landlords and the courts in matters of enhancement and eviction. Accordingly Act X. of 1859 (India) was passed for the regulation of rent questions in Bengal, Agra, and Central Provinces. Generally under native rule the cultivator was not ousted from his holding provided he paid his dues. Besides these cultivators there was a class of men on a more temporary footing, who came from outside villages or wandered from place to place, and to whom it was felt that the same customary obligation did not apply. Consequently the Act of 1859 divided the tenants into "occupancy" and "non-occupancy", and gave the former a larger degree of protection. It provided that the continuous cultivation or holding of land for twelve years entitled the tenant to a "right of occupancy".

In various local Acts passed subsequently, a similar distinction was observed. Eventually it was found that the pressure of high rents entailed a great deal of unnecessary poverty, and this led to the passing of the Bengal Act in 1885, which has been accepted in many respects as the standard of rent legislation for India, and, combined with the recommendations of the Famine Commission in 1880, led to the gradual revision of the rent legislation of other provinces. Although the specific provisions of the laws differ, there is a general similarity in their outline in Bengal, Agra, and the Central Provinces. The provincial legislation has local peculiarities in Oudh, where the land is principally owned by large proprietors, and in the Punjab, where the owners are small farmers and only half of the land is let to tenants.

At the present time the law recognises two main classes of tenants, occupancy and non-occupancy, in all the provinces above mentioned. In Bengal and Agra only is a twelve-year rule now followed as a qualification for occupancy rights. Rights of occupancy were granted to certain classes of ex-proprietors only in Oudh, but in the Punjab they can be claimed on certain specified historical grounds, but not on mere lapse of time. In the Central Provinces, the twelve-year rule was suspended, in 1884, by a provision that permits the purchase of occupancy rights by an ordinary tenant at two and a half times the annual rent. In Bengal, a tenant who has continuously held land in a village for twelve years has a right of occupancy in all land that may at any time be held by him in that village. In Agra, special precautions have been taken to prevent the deliberate shifting of tenants by the landlord; the tenants' continuous possession is held not to be disturbed by redistribution or exchange of holdings.

The Act of 1859 allowed enhancement up to the prevalent standard of occupancy rents in the neighbourhood, or up to a limit indicated by a rise in the value of produce. An increase in the area of the holding, or landlord's improvements, are everywhere accepted as proper grounds for enhancement. Subject to certain conditions, an occupancy tenant's rent can generally be enhanced by contract, but in some provinces the interposition of a Government officer is in any case required. If an enhancement is made on suit or application, it is subject to certain prescribed limitations. Rent may be

altered at the time of the revenue settlement in all provinces where the land revenue is subject to periodical reassessment. Except on the ground of change of area or landlord's improvements, an occupancy rent once fixed is, however, unalterable for a further term of five, ten, or fifteen years; the term is shortest in Oudh and longest in Bengal. Except in the Punjab, even the rent of a non-occupancy tenant is not left entirely to the decision of the landlord. Once a non-occupancy rent has been fixed, it is generally protected from further enhancement for a period of five or seven years.

As regards rent abatement, generally it can be adjudged on conditions inverse to those permitting judicial enhancement; and a Government officer who has power to fix fair rents is necessarily also invested with the power to reduce excessive rents.

With regard to the recovery of rent arrears, legislation tends to reduce the landlord's summary powers of recovery and to simplify the procedure of recovery through the courts. Possible oppression in the matter of distraint and ejectment is accorded considerable safeguards.

Rents are far less prevalent in the ryotwari areas, where large proprietors are non-existent and the land is cultivated to a much greater extent by the landowners themselves, and where the Government deals directly with each occupant of land.

Kind-rent, the original form of rent in India, which generally comprised a share of the grain heap, still obtains to a large extent in undeveloped districts, and where the tenants are poor and depressed. Otherwise its payment is largely a matter of custom. The disadvantages associated with this system are the possibility of fraud, uncertainty, and oppression, but it apportions the rent exactly to the produce and does not press so hard on a tenant in lean years.

To a large extent custom is still the foundation of Indian rents, and rent legislation starts from this basis; it accepts the legitimate influence of competition, and does not aim so much at the curtailment of advantages naturally accruing to landlords as at the maintenance of rights already conferred on tenants by custom. The incidence of cash rent per cultivated acre varies from 0·7 rupee in the Central Provinces to 5·2 rupees in Oudh. Tenants hold 54·1 per

cent of the cultivated area in the Punjab and 77·1 per cent in the Central Provinces. The average area held by proprietors varies from 16 acres in Agra to 335 acres in the Central Provinces.

The Co-operative Movement.—The passing of the Co-operative Credit Societies Act in 1904 marks the beginning of the development of co-operation in India. Probably no field offered a wider avenue for its benefits than agriculture. The movement progressed with remarkable rapidity, for, within ten years of the passing of the Act, it possessed a working capital of Rs. 5,000,000, with a membership of 600,000. The primary object of the law was to deal with the “status of stagnation” of the poorer classes, and of which the agricultural class predominates. The farmer’s most pressing need was for aid in prosecuting his operations without falling still further into a state of practical dependence on the money-lender. It was therefore necessary to provide capital as cheaply as possible, and facilitate his spending it to the best advantage by buying as cheaply as possible. Obviously, when a farmer is only making a sparse living from his land, he is unable to invest in improvements, at any rate until his income increases sufficiently to have money to spare, and it is small wonder if agricultural demonstrations and advice are unappreciated. The circumstances of the average Indian farmer, as regards lack of capital and equipment, afforded ample scope for the co-operative movement. The credit side of the co-operative movement thus developed first in India. It assisted the farmer to overcome the difficulties necessarily associated with the lack of available capital, and in many districts the cheap credit provided by the societies forced the local money-lenders to lower their rates of interest.

Legislative protection was given later, by the Co-operative Society’s Act of 1912, to co-operative societies organised for distribution and for purposes other than credit, in addition to the Central Banks, Unions, etc., which had been formed to finance and to control the original credit societies. New types of societies evolved for the sale of produce, manure purchase, cattle insurance, etc. The movement greatly facilitated the distribution throughout large areas of the improved cotton seed from the Government farms, the

maintenance of the purity of the seed, and the sale of the crops resulting therefrom in the best market. Cheap fertilisers and implements, after being tested and approved by agricultural experts, and useful information on agricultural subjects, it also made readily available to the farmer. It was largely used by the Agricultural Department in connection with its object lessons and demonstrations, for organised bodies of farmers are more easily approached by agricultural advisers than isolated individuals.

In the Central Provinces agricultural unions, consisting of co-operative societies, or independent of pre-existing societies, were organised. They maintain a central farm for the production of the improved cotton seed supplied annually by the Agricultural Department, and provide ginning machinery for ginning the improved cotton grown on the branch farms worked by the members. In Burma, many co-operative associations have been constituted for the purpose of establishing co-operative ginneries. Similar organisations also exist in other provinces. Societies have been formed in the Bombay Presidency to grow improved cotton on farms of selected growers, and to gin this cotton separately and to sell the seed. Other societies were inaugurated in this presidency for the purpose of ensuring the correct weighing of cotton, the procuring of better prices, and the elimination of unnecessary middlemen. They were entrusted by the Agricultural Department with the auction of the improved Cambodia and Broach cottons, which resulted in record prices being obtained. In the Punjab, societies were formed for the sale of improved American cotton; these societies insist on their members growing only pure American cotton and the eradication of all native cotton.

Long v. Short Staple.—The question of improving the quality of Indian cotton has occupied the attention of the Government of India since 1788. Originally its primary object was to render Lancashire independent of the American crop, but to-day this aspect of the problem is made more difficult of solution by the circumstance that India now possesses a flourishing cotton-manufacturing industry, which is equally interested in procuring larger supplies of superior cotton. Short staple cotton is reported by certain authorities to be more profitable to the farmer, for it is more hardy, being

less susceptible to seasonal vicissitudes, and gives a higher yield and ginning out-turn.

The problem of growing more cotton in India is really an economic one, for it comes into competition with several common Indian crops, and its more extensive cultivation is dependent upon its relative value as compared with that of them. With the possible exception of jute, cotton is most affected by market values. With almost any other crop, a good harvest means good returns, but in the case of cotton, the whole crop may be left in the growers' hands, through influences over which he has no control, and are totally beyond his understanding, which naturally creates anxiety in a community that is entirely dependent on the land for its means of sustenance. It is therefore obviously undesirable to concentrate attention to this crop to the detriment of others of equal or even greater importance. It is also problematical whether attention should be devoted mainly to long or to short staple cotton.

India is peculiarly adapted for the production of coarse cottons spinning under 20's, and for which there is a strong and increasing demand; whereas the production of long staple cotton is mainly restricted to those areas where irrigation facilities obtain. Moreover the latter types are more delicate and are more readily affected by adverse climatic conditions, and require greater care in cultivation, picking, and preparation for market. Fully 75 per cent of the crop has a staple which does not exceed $\frac{3}{4}$ inch in length, while only 15 per cent of the crop is suitable for the Lancashire market, even if it were all available for this purpose. Indian cotton mills now annually absorb $2\frac{1}{2}$ million bales, which is approximately one-half of the Indian crop, and they take 80 per cent of the present supply of Indian cotton of good staple. Despite the fact that Lancashire does not use much Indian cotton, it is important to bear in mind that every additional bale of cotton produced in India releases a bale of American cotton and decreases the demand for it. It is estimated that the consumption of cotton per head of population in India is about $3\frac{3}{4}$ lb., which is equivalent to $3\frac{1}{4}$ million bales of lint. Japan is India's best customer for raw cotton, purchasing from 1 to $1\frac{1}{2}$ million bales, of which five-sixths is very short staple cotton that is

quite unsuitable for the Lancashire manufacturing industry. Recent reports indicate that within five years, and as the various large irrigation schemes under construction develop, India's crop will reach 6 million bales, of which 2 million bales will have a staple of $1\frac{1}{16}$ to $1\frac{1}{8}$ inch.

Indian Cottons.—The deterioration of Indian cotton has been the subject of much complaint in England, but this has been met by Indian authorities with the statement that “there is little evidence to show that the quality of any particular variety has actually deteriorated, but apparent deterioration is due to intentional mixture in the trade, seasonal differences, and substitution of hardier varieties giving inferior lint that are more profitable to the grower”.

Indian indigenous cottons may be broadly divided into two groups: (1) those which require eight months to reach maturity, and (2) those which ripen in five months. The varieties included in the first group are only suited for cultivation in districts where there is a deep, moisture-holding, black soil, or a prolonged wet season. In the north of India they fail because the December cold arrests their growth before they arrive at maturity. The plants are bushy and prolific, and they produce lint of fair length and quality. The proportion of lint to seed cotton is 35 per cent in the best Broach varieties, and less than 25 per cent in the poor Madras varieties. The varieties in the second group are much more numerous, and are more widely grown. With few exceptions, they produce cotton which is short and coarse, but pure white in colour, and the shortest and coarsest is used for mixing with wool. In the coarsest varieties, the percentage of lint to seed cotton ranges from 30 to 50. The plants are tall, with few side branches, and individually are not very productive. Their cultivation has been considerably extended, because they are hardy and can be grown on soils that are unsuited, without irrigation, for the late ripening varieties. In average years the early ripening varieties give good yields, and they can be grown without much risk in years of short rainfall.

In 1921-22 the estimated percentage of different recognised trade descriptions of Indian cottons produced was: Oomras 55, Bengal-Sind 16, Dholleras 10, Tinnevellies, Salems, and Cambodias 6, Kumpta Dharwars 4, Broach 4.

Efforts to improve Indian Cotton.—The earliest efforts directed to the improvement of Indian cotton were based on the idea that there was no possibility of permanently improving any of the indigenous varieties, and that success was only to be achieved by the introduction of exotic varieties possessing the desired characteristics, but without due regard to their suitability to local conditions.

The numerous agricultural experiments conducted in the nineteenth century, mostly confined to exotic varieties, by staffs of experts from America and elsewhere, resulted in failure and were abandoned, with a single exception, which was the establishment of the variety now recognised as Cawn-pore American. If these early efforts did not yield gratifying results, they amply demonstrated the fallacious policy of foisting Western ideas and methods, without due consideration of local conditions, on the local farmers, who, in the majority of cases, had sound reasons for their practice, and indicated that the proper scope for development lay in improving indigenous methods.

Special attention began to be devoted to this problem in 1900, and careful investigation disclosed the immense complexity of the conditions affecting the crop, and the difficulty of securing immediate success in regard to staple improvement. Certain authorities have maintained that the agricultural prosperity of India is less likely to be benefited by improving the quality of cotton than by improving the out-turn, cultivation, and trade practices affecting ordinary indigenous varieties, because the principal and most profitable demand is that for coarse cotton to mix with wool for the manufacture of cheap, warm clothing. Further, that in most areas the best results would accrue from working with indigenous varieties as a basis.

The Director of Agriculture, Bombay, has expressed the opinion that "American cotton cannot be grown successfully in India. Recent introductions in the Punjab have deteriorated in quality and yield, and this year (1922) the quality has gone off altogether. The only course open is to improve the plant, from within India, by selection from the different types growing." In any case the general experience throughout India has been that American types only succeed on light soils, with a well-distributed rainfall, or under

irrigation, and, in common with all imported varieties, they only succeed after acclimatisation.

In 1902 a collection was begun of all existing varieties cultivated in India, for sowing at Poona and other centres. A valuation of their lint was made by trade experts, and the lint percentage of each variety was determined. These were distributed to the various Agricultural Experiment Stations to serve as a basis for botanical examination and identification, and to test for the most suitable varieties to grow in each area. It was discovered that most of the varieties had inherent characteristics which suit local conditions. For example, the fine Broach type deteriorates when it is removed from the genial influence of sea breezes; extensive trials in various regions proved a general failure, for the plants were damaged by the heavy monsoon rains and winter cold. Tests in Sind, with over 300 indigenous varieties from all parts of India, showed that none equalled the local Sind cotton in cropping power.

These collections proved in process of time a complete representation of the numerous types of cotton grown in India. Their classification was undertaken by Professor Gammie; it "essayed no violent departure from any of the usually accepted methods of classification, its only novel feature being that it emphasised the necessity of subordinating botanical requirement to agricultural needs, in the account of an Indian genus so highly domesticated that it is difficult to assert that any form exists in a truly wild condition in the country". Although this classification is not accepted by all botanists, it is the one generally followed by the Indian Agricultural Departments, and it has been adopted in this chapter.

As so many of the conditions which govern the Indian cotton industry differ so widely in different parts of the country, it is considered advisable to deal with each important cotton-growing province separately; in this connection much valuable data has been extracted from the report of the Indian Cotton Committee, which was published in 1919. This committee was appointed by the Government of India to investigate the possibilities of extending the growth of long staple cotton in India, as well as other matters affecting the cotton industry.

BOMBAY

The area of the Bombay Presidency, exclusive of Sind and the Native States, is 48,642,700 acres ; some 26,161,000 acres are cropped, of which about 4 million acres are under cotton. The percentage of the area under cotton to the total cropped area is thus over 15 per cent, which is only exceeded in Baroda and the Central Provinces and Berar, while it comprises about 17·7 per cent of the total area under cotton cultivation in India. The Native States in the presidency have an area of 2,190,000 acres under cotton, which represents 9·8 per cent of the total area under cotton in India. Bombay and Baroda together are the most important cotton-growing regions in India, and it is therefore not to be wondered at that the problems connected with cotton are more complex and difficult than they are elsewhere.

The Bombay cotton-growing regions may be conveniently separated into four main divisions, which, respectively, produce the cotton known in the trade as: (1) Dholleras, (2) Broach, (3) Khandesh, and (4) Kumpta - Dharwar. The Dholleras division comprises the greater part of north Gujarat, *i.e.* the Ahmadabad and a portion of the Kaira and Panch Mahals districts, the adjoining part of the Baroda State, and the greater part of Kathiawar. The Broach division, which lies immediately south of the former, comprises south Gujarat, the Broach and Surat districts in British territory, the adjacent portions of the Baroda State, while outlying portions of it extend into Kathiawar. The Khandesh division comprises the Nasik, Ahmednagar, and Sholapur districts and the northern part of the Bijapur district. With the exception of the last mentioned, all these districts form part of the Bombay Deccan. The Kumpta-Dharwar division comprises the districts of Dharwar, Belgaum, and the greater part of Bijapur, and several Native States, of which Kolhapur and Sangli are the most important, which together form that portion of Bombay which is known as the Karnatak.

Climate.—The climate of the various cotton-growing regions of Bombay differs very considerably. Gujarat has a pleasant cold season, with oppressive heat in the summer months. Its rainfall of 30 to 40 inches is mainly received from the south-west monsoon. At the burst of the monsoon

the temperature falls, but the atmosphere remains hot and sultry until October. The climate of the Deccan districts is very hot from March to May, but fairly temperate for the rest of the year; the bulk of the rainfall of 20 to 30 inches is likewise received from the south-west monsoon, although in October heavy storms occur from the north-east. In the Karnatak districts more rain is received from the north-east monsoon than in the other cotton-growing areas, and extremes of temperature are not so marked. The climatic conditions of Bijapur differ little from those of the Deccan, but the remaining areas have a heavier rainfall, the average at Belgaum being 52·3 inches.

Soils.—Extensive tracts of black cotton soil are found in Broach and Surat, which is supposed to be the result of the alluvium brought down by the Tapti and Narbada rivers. Broach originally produced the best cotton exported from India. In Gujarat are also found alluvial soils, of great depth, varying from the drift sands of Ahmadabad to the rich loam of Kaira. Black cotton soil is prevalent in the Deccan and Karnatak; it originates from the weathering of the trap rock and varies greatly in texture and in depth.

Varieties of Cotton grown.—The botanical aspect of the Bombay cotton industry presents greater problems than that of any other part of India, and the Dholleras cotton is especially diverse in this respect. Prior to 1900 Dholleras cotton was principally composed of a variety of *G. herbaceum* known as *lalio*, with a staple of $\frac{5}{8}$ to $\frac{3}{4}$ inch and a ginning percentage of 33, but this has been replaced by a mixture of varieties. An approximately pure type of *G. herbaceum* known as *wagad*, with a staple of $\frac{3}{4}$ to $\frac{7}{8}$ inch and a ginning percentage of 33, is grown in the neighbourhood of Viramgam, in the Ahmadabad district, and in parts of Kathiawar and Cutch. A peculiarity of this cotton is that the bolls do not open, even when they are ripe, so they are picked whole and the cotton is extracted subsequently. A mixture of Broach and *goghari* known as *kanvi*, with a staple of $\frac{1}{2}$ to $\frac{5}{8}$ inch and a ginning percentage of 35, and *goghari*, an inferior variety of *G. herbaceum*, with a staple of $\frac{1}{2}$ to $\frac{5}{8}$ inch and a ginning percentage of 40, are grown in Kaira and Panch Mahals districts and in the Daskroi taluka¹ of Ahmadabad. Throughout large areas of Ahmada-

¹ Taluka = revenue subdivision of a district.

bad and Kathiawar, *mathio* is the principal cotton grown ; it is a mixture resembling that of Khandesh, described below, to which is added *G. neglectum kathiawarens*. Other predominating forms of *G. neglectum* in this mixture are *G. n. cutchicum* and *G. n. roseum* ; the staple length of the mixture is $\frac{1}{2}$ to $\frac{5}{8}$ inch and the ginning percentage is 32. A perennial variety of *G. obtusifolium*, known as *rozi* or *jaria*, with a staple of $\frac{1}{2}$ to $\frac{5}{8}$ inch and a ginning percentage of 35, occurs in the Kaira district.

With the exception of small quantities of Bourbon cotton, *G. purpurascens*, *G. herbaceum* is the only species grown in the Broach division. Cotton grown in Surat has a staple of $\frac{7}{8}$ inch and a ginning percentage of 32 ; that grown in Navsari has a staple of 1 inch and a ginning percentage of 31. Owing to its high ginning percentage, *goghari* cotton has become very popular and has replaced the excellent cotton formerly grown in the Broach district north of the Narbada and the adjacent portions of Baroda. Unless measures are taken to check it, it is considered that this variety will not only continue to extend in these districts, but also in Surat and Navsari. It is obviously not to the cultivator's interests to allow the quality of Broach cotton to continue to deteriorate in this manner, in view of the great trade reputation that it gained some years ago. Success has attended the efforts to replace the mixed cottons in the Surat-Broach tract with pure strains of superior staple. South of Tapti, *goghari* has been almost entirely eliminated and the character of the district as a producer of staple cotton is practically re-established. This has been accomplished by the multiplication and distribution of pure seed from 18,000 acres of private farms.

In the Khandesh division, a mixture of varieties of *G. neglectum* is grown, which has a staple of $\frac{1}{2}$ to $\frac{5}{8}$ inch and a ginning percentage of 32. The mixture consists of *G. n. malvense*, *G. n. verum*, *G. n. cutchicum*, *G. n. roseum*, together with a small proportion of an Upland Georgia variety. This mixture is being gradually replaced by a pure variety of *G. n. roseum*, which has a staple of $\frac{3}{8}$ to $\frac{1}{2}$ inch and a ginning percentage of 38.

The principal cotton grown in the Kumpta-Dharwar division is Kumpta, a variety of *G. herbaceum* with a staple of $\frac{7}{8}$ inch and a ginning percentage of 26. A pure type of

Kumpta known as Dharwar No. 1 is said to be rapidly replacing ordinary Kumpta cotton in Dharwar, south Bijapur, and south Belgaum. Dharwar-American cotton is usually grown along with Kumpta, but, as it ripens earlier than the latter, both kinds are said to be marketed in a fairly pure condition. Dharwar-American cotton is a mixture of Upland Georgia and New Orleans cotton; it has a staple of $\frac{3}{4}$ to $\frac{7}{8}$ inch and a ginning percentage of 30. In the Gadag and Ron talukas of the Dharwar district, Cambodia cotton, a form of Upland Georgia cotton, which was introduced to India from Cochin-China, is grown on about 5000 acres, while a similar area in the Dharwar district is grown with Dharwar-Broach cotton. It has, however, been found that Cambodia cotton suffers severely from rain after germination, to which the Dharwar-American mixture is less sensitive. Moreover, through the usual lack of care the growers have permitted the Cambodia cotton to become mixed in the field, and there has been a marked deterioration of its staple.

Little success has attended the numerous attempts to introduce exotic cottons into Bombay, and there appears to be little prospect for them, except in the Kumpta-Dharwar area. It is therefore considered that efforts to improve the cotton should be primarily devoted to the indigenous varieties. In this connection it is suggested that steps should be taken to maintain the purity of *wagad*, and to restore the purity of *lalio*. The relative value of the constituents of the Dholleras mixture should also be determined. As a result of work of this nature carried out with the local varieties in the Khandesh division, it has been found that *G. n. roseum* is the most profitable, both in point of yield and ginning percentage, and it is now grown on a considerable scale. It has given 100 lb. more of seed cotton per acre than the ordinary Khandesh mixture. Besides being superior as regards ginning out-turn, the lint is sold at a premium on account of its colour.

Investigations conducted at the Gadag farm have shown that the Upland Georgia type in the Dharwar-American mixture is less susceptible to adverse climatic conditions and insect attack than the New Orleans type, so efforts are being made to eliminate the latter.

The cotton industry of the Native States of Bombay is of considerable importance, for the area cultivated with cotton

represents about 10 per cent of the total area under cotton in India. Many of their rulers and high officials exhibit a keen interest in the agricultural development of their territories. In Kathiawar, the States of Morvi, Wadhwan, Muli, Wankaner, and Lakhtar grow *wagad* and *kanvi* and patches of *lalio* under irrigation. The remaining States in Kathiawar grow *mathio* over large areas.

Improved strains of cotton distributed from the Surat experiment farm have been grown in certain villages, where the cultivators select a committee, of which the Divisional Superintendent of Agriculture is chairman, which supervises everything from the distribution of the seed to the marketing of the produce. The lint sells at a premium over ordinary local cotton, and the seed is returned to the Surat farm for storage and distribution in the following season. In Khandesh, *roseum* seed is given from the Jalgaon experiment farm to seed societies, which distribute it to their members who have good land and have a reputation for agricultural skill. Conditions attaching to this distribution are: that the first two pickings shall be kept separate and be ginned at a factory selected by the committee, and that the growers shall sell the lint separately and hand back the seed to the committee at a price fixed for it. In addition, co-operative sale societies have been established in Khandesh for the purpose of securing for their members the full value of their cotton. The Agricultural Department has organised auction sales in the Kumpta-Dharwar area for the disposal of the Dharwar Broach and Cambodia cotton; at these auctions only the produce of certified growers is accepted for sale.

As it was observed that some of the Dharwar-American plants produced glabrous and others hairy leaves, and that there existed a correlation between hairiness and resistance to the fungus disease known as Red Leaf Blight, a hairy-leaved variety has been selected known as Gadag I., which resists this blight to a considerable extent. It bears large bolls and yields better, besides showing considerable advantage as regards ginning percentage and staple. It has been maintained pure by selling a large number of flowers yearly and sowing selfed seed in the Dharwar farm, where there is no danger of deterioration by natural crossing. The cultivators are reported to be taking readily to the new variety, and local

merchants and mill owners have shown their appreciation of its superior quality by paying a good premium for the crop.

Cultivation. — Throughout the Bombay Presidency, the cultivation of cotton is very good compared with other parts of India. In the Broach and Surat areas it is probably even more thorough and advanced than in any other part of India. Tillage usually commences in the hot weather with a heavy scarifier, which extracts the stubble of the previous crop, scrapes the surface, and fills in the soil cracks. Any available manure is applied in May. After the first monsoon rain, the plough is worked several times so as to have the land in good condition for planting in June. The seed is planted in straight equidistant rows with a 2-row drill having coulters 20 to 22 inches apart. To overcome the difficulty of passing fuzzy seed through the drill, prior to sowing they are mixed with a compound of cow dung, mud, and water, and then dried. Seed is planted at the rate of 10 to 15 lb. per acre, but two or more sowings may be necessary to secure a regular stand of plants, on account of damage from rain on the heavy black soil. Generally the crop is hand weeded once or twice. The weakly seedlings are gradually thinned out until the strongest plants are left 18 to 24 inches apart in the rows, or closer if the plants are backward or stunted from any cause. When the seedlings are about 4 inches high, interculture commences with the bullock hoe. In order to prevent the soil cracking too early and to conserve moisture, the plough is passed between the rows in September or October as a final cultural operation. The plants commence to flower in October. Cotton picking begins in January and continues until March, four or five pickings being usually necessary.

The land is seldom ploughed in Gujarat or where heavy soils obtain, as in Khandesh, but it is harrowed during the dry season after the harvest of the preceding crop. On the light soils of Khandesh and throughout Karnatak, ploughing is generally practised. In the latter region, hand digging is sometimes carried out because of the prevalence of deeply rooted weeds. Weeds of this nature are very common in north Gujarat, and they occur throughout the Deccan as well as in large tracts in Khandesh. In Gujarat, *Cyperus rotundus* is prevalent, while *Cynodon dactylon* and *Ischaemum pilosum* are most troublesome and prove serious enemies to

cotton in the Deccan and the Karnatak. In the latter region moderate success has been achieved by the Agricultural Department with gear and steam ploughs, in the eradication of deeply rooted weeds. It is considered that there is great scope for development in this direction. Although cotton is planted with drills throughout the presidency, much advantage would accrue from the general adoption of a drill that dropped the seeds at proper intervals, both in Bombay and elsewhere. Planting takes place in north Gujarat and Khandesh in June, in south Gujarat from June to September, and in the Karnatak it commences at the end of August and extends into September.

Rice, as a subordinate crop, is sometimes grown in the same row or in alternate rows with cotton on deep retentive soils, and where a good rainfall obtains in Broach. Other crops grown with cotton, especially when there are gaps in the cotton crop, are sesamum, gram, coriander, and other condiments. *Bajra*, *Pennisetum typhoideum*, is invariably grown in rows with the perennial *rozi* cotton in Kaira.

Generally cotton is grown in alternate years and sometimes in two successive years, for it occupies such an unusually large proportion of the cropped area that a three-year rotation is rarely met with. The commonest rotation practised in the presidency is cotton and *juar*, *Sorghum vulgare*. *Bajra*, *Pennisetum typhoideum*, replaces *juar* on the light soil of the Dholleras division, while wheat is sometimes substituted for it on the heavy soils. *Lang*, *Lathyrus sativus*, wheat or *tur*, *Cajanus indicus*, frequently takes the place of *juar* in the Broach area. The introduction of leguminous crops, especially ground nut, into the rotation, and of the cultivation of *sann* hemp, *Crotalaria juncea*, with cotton, as a green manure, has been effected by the Agricultural Department in the Broach area, while the cultivation of ground nut as a rotation crop is spreading in Khandesh. Fallowing is also largely practised. Cotton is often planted in rows from 6 to 12 feet apart, and the unoccupied land is thoroughly cultivated in readiness for cotton planting in the following season. Interculture is also efficiently carried out in Khandesh.

Farmyard manure is the commonest fertiliser used, but the supply is very limited, and it is seldom applied more than

once in three years. The application of commercial fertilisers to cotton is reported to have proved unprofitable. In Gujarat and Khandesh, excellent results have been obtained by the application of poudrette and crude night soil to cotton, but their use is no more popular than in other parts of India. The use of castor-oil cake is increasing in Kandesh ; this is probably the first instance of the extensive application of a concentrated fertiliser to a dry, unirrigated crop in western India.

Cotton under well irrigation has given increased yields in the Kaira district ; this is the only form of irrigated cotton grown in Bombay. In view of the success attained at Kaira, it appears to be desirable to increase the number of wells in north Gujarat. Considerable progress has been made through the activities of the Agricultural Department, in the direction of replacing bullock power by pumps.

Cotton Picking.—In Gujarat, picking commences in January and continues until April and May, so that the growing season has a duration of 200 days. The growing season is shorter in Khandesh, where picking begins in October and ends in December. In the Karnatak, picking takes place from March to May.

CENTRAL PROVINCES AND BERAR

Exclusive of Native States, the area of the Central Provinces and Berar is 63,966,450 acres, of which the total cropped area is 24,985,000 acres, and the area under cotton is 4,475,000 acres. The percentage under cotton in the total cropped area is thus 17·9, which, with the single exception of Baroda, is higher than that in any other province or Native State in India. The importance of cotton is still more striking if the figures for Berar are taken separately, where the percentage of the cotton area to the total cropped area is 45.

Climate and Soil.—In the most important cotton-growing regions, which comprise the four districts of Berar and the adjoining districts of Nimar, Wardha, and Nagpur, the climate is intensely hot and dry from March to May, and temperate for the remainder of the year. The Arabian Sea current of the south-west monsoon supplies the bulk of the

rainfall, which varies from 27·61 inches for the Akola district to 46·68 for the Nagpur district. Normally the monsoon breaks on the 10th of June. Rainfall due to the advance of the monsoon usually ends in October, but isolated showers are received from the retreating current in November and December.

A rich black and fertile loam, often of great depth, is the prevalent soil of Berar, and is identical with that which is commonly described as "black cotton soil". The Nagpur plain is the principal cotton-growing region of the Central Provinces, where the loam is rather shallower than that of Berar.

Varieties of Cotton grown.—The cottons of the Central Provinces and Berar were classified, until 1870, as Chanda *jari*, *bani* or Hinganghat, and Berar *jari* or Oomras. Chanda *jari* and *bani* was the same variety under different names. The *jari* or Oomras of Berar was slightly inferior to *bani*. An inferior variety of cotton, known as Nagpur *jari*, *kati vilayati* or old Khandesh, rapidly spread to the detriment of superior cotton in Khandesh. In 1870 attempts were made to eradicate it, which caused it to spread into Berar, where cultivators found it more profitable than the old varieties. Although Government prohibited its cultivation in 1874 and again in 1880, its cultivation has never been abandoned.

Experiments with exotic cottons date back to 1839. American and Egyptian varieties were extensively tested without success. The only survival of these experiments is a variety of Upland Georgia, of which seed was distributed from the Nagpur experiment farm for several years commencing in 1903; but the work was eventually abandoned as the yield was less than that of the ordinary *jari* mixture, and the premium offered over *jari* did not compensate the growers.

An attempt by the Agricultural Department, in 1904, to encourage the planting of *bani* in place of *jari* likewise failed, as the yield was less and buyers offered a lower price for the seed cotton on account of its inferior ginning percentage. In its pure state *bani*, *G. indicum*, is probably the finest native cotton in India, for it has a staple of 1 to 1½ inch, a ginning percentage of 25 and its lint is strong and silky; unfortunately in this state it has almost entirely disappeared from

the provinces. Probably not more than 10,000 acres are now planted with it, including 6000 acres grown as a cold-season crop in Chanda. It is considered probable that it was this cotton from which the wonderful Dacca muslins were made.

The cottons now grown in the Central Provinces and Berar comprise a mixture of varieties, in which *G. neglectum* greatly predominates. Besides the varieties mentioned above, the following are also included in this mixture: *G. n. malvense*, staple $\frac{3}{4}$ to $\frac{7}{8}$ inch and ginning percentage 25; *G. n. verum*, staple $\frac{5}{8}$ to $\frac{3}{4}$ inch and ginning percentage 30; *G. n. roseum*, staple $\frac{1}{2}$ to $\frac{5}{8}$ inch and ginning percentage 40; and *G. n. cutchicum*, staple $\frac{1}{2}$ to $\frac{5}{8}$ inch and ginning percentage 39. The average staple of the mixture is $\frac{5}{8}$ to $\frac{3}{4}$ inch. Where the mixture comprises a high percentage of *G. n. verum* and *G. n. malvense*, as in the north of the provinces, the ginning percentage is 33, but where *G. n. roseum* and *G. n. cutchicum* occur more abundantly, as in Berar, the ginning percentage is 35.

Work which was commenced by the Agricultural Department at the Akola experiment farm, in 1907, in separating the constituents of the *jari* mixture, definitely established the superiority of *roseum* over the other components of the mixture, both as regards yield and ginning percentage, and it is reported that it is now grown pure on 700,000 acres.

On the porous, laterific soils of the Chattisgarh division, Cambodia cotton is grown under irrigation on a small area, where it has yielded as much as 7 cwt. of seed cotton per acre with six irrigations. In the western portion of this division, where the rainfall is high, there seems to be a possibility of growing Cambodia without irrigation on the black soils. This cotton has been successfully grown under irrigation in the neighbourhood of Chandkuri, but irrigation facilities are such that not more than 7000 acres of irrigable land are likely to be available in the near future. It has been suggested that the possibility of extending the area under irrigation, by pumping, on the light laterific soils in this division, deserves to be investigated. A type of American cotton, known locally as *buri*, *G. hirsutum*, staple $\frac{7}{8}$ to 1 inch and ginning percentage 31, which was introduced by the Agricultural Department some sixteen years ago, from the Santhal Parganas, is also grown pure on about 2000 acres.

A premium is usually paid for *roseum* seed cotton over that of the ordinary *jari* mixture of Berar ; this is because the ginning percentage of the former is higher, and despite the fact that *jari* cotton has a longer staple. Usually the lint of *roseum* is also sold at a higher price than that of *jari*, probably because up-country cotton is bought almost entirely on class and grade without regard to length of staple. It should be mentioned that the lint of *roseum* is always cleaner, owing to the way the bolls open, than that of the other varieties of *neglectum*. Experiments have demonstrated the yield of lint per acre of *roseum* and *verum* to be 128 and 88 lb. respectively. Attempts to grow long staple cotton have been mainly concentrated on the improvement and extending the area under cultivation of the native variety *bani*, which has not been able to compete with the coarser varieties, that are superior in yield and ginning percentage. An improved variety of this type, which, in 1920-21, was grown on 363,370 acres, gave an increased profit of 4 to 14 Rs. per acre over the local varieties.

Cultivation.—The cotton crop of the Central Provinces and Berar is usually grown without irrigation. Unless the land becomes infested with weeds, it is rarely ploughed, but is merely scratched with a blade harrow prior to planting. The seed is planted, usually in lines, in June soon after the break of the monsoon. Interculture is carried out with a narrower type of blade harrow than that used for preparing the land for planting. These implements need to be supplemented by some that will thoroughly break up the soil towards the end of the rains, so as to form a loose soil mulch to conserve soil moisture. For this purpose the Agricultural Department has introduced an improved hoe, known as the Akola hoe. Cotton and *juar*, *Sorghum vulgare*, in alternate years, is the usual rotation, but cotton is often grown for two or three years in succession. It is considered that a high-yielding leguminous fodder crop could be advantageously introduced into the rotation, either instead of or along with *juar*.

Picking usually begins in October and continues until December ; but where irrigation is practised it continues until March. Generally from five to seven pickings are made. Cotton is not damaged by frost, except occasionally in the northern districts, but the period of growth is

limited by the lack of moisture in November and December. For unirrigated cotton the season lasts for 140 to 150 days.

Seed Distribution.—Striking success has been achieved by the organisation that has developed for the distribution of the pure seed of the *roseum* variety. Originally the seed farms in Berar were supplied with seed from the central farm at Akola; but owing to the progress made by 1912 it was recognised that this procedure had its limitations, and, moreover, difficulty was experienced in providing the necessary supervision by the Agricultural Department. As a consequence, an intermediary between the Government farm and the private seed grower was introduced in the form of the Agricultural Union. As a preliminary measure, six Agricultural Unions were registered as co-operative societies, and subsequently twenty-five additional, but unregistered, Unions were established. Originally it was intended that each Union should control some 500 acres under improved cotton seed, and pay the wages of a fieldman who had been trained by the Agricultural Department. The principal duties of the fieldman are to see that all varieties of cotton, other than *roseum*, are “rogued” out of the fields, and to assist with seed distribution. Each Union has a central farm of about 100 acres, and the Agricultural Department supplies it with seed in preference to other purchasers. The Union’s central farm supplies seed in turn to its branch farms, which number about thirty-five, and have an average area of 20 acres each. The members store their seed cotton until it can be brought to the Union’s ginnery. The members may elect: (1) to have their crop ginned at the Union ginnery and remove the lint, leaving the seed in the Union store house until they require it; (2) to sell their seed cotton, but buy back their seed at the prevailing rate, but the seed cotton must be ginned at the Union ginnery; (3) to sell either the seed cotton or the lint and seed, as they decide. The seed supplied by the central farm to the branch farms is charged for at the same rate as that fixed by the Agricultural Department for the seed which it supplies to the central farms. In 1917 this rate was two and a half times the price charged for ordinary local seed in the market. Seed is sold by the branch farms to outsiders at the same rate. In 1916 there were 51 Agricultural Unions and 513 seed farms, some of which were not attached

to Agricultural Unions. In 1917 these Unions distributed sufficient *roseum* seed to plant 200,000 acres.

In each subdivision of a district in the Central Provinces and Berar cotton-growing regions, a Taluk Agricultural Association has been established, and the work of the Agricultural Unions is co-ordinated to a large extent by it, and of which the principal members of the Agricultural Unions are also members. Central District Boards have allocated funds to the Taluk Agricultural Associations to enable them to carry out useful work with the aid of paid workers. Although seed distribution is at present the principal function of the Agricultural Unions and Taluk Associations, they are engaged in other agricultural development work such as the sale of improved implements and fertilisers.

HYDERABAD

The area under cotton cultivation in this State is about 3,262,000 acres, which constitutes 14·7 per cent of the total area under cotton in India ; Bombay and the Central Provinces and Berar are the only parts of India which return a greater area and percentage.

A line drawn due north and south through the Capital city of Hyderabad separates the State into two almost equal and well-defined divisions. East of this line is the region known as Telingana, and west of it are the Mahratwarra and the Caranese regions. In the latter division the climate is usually hot and dry from March until the end of May, and temperate for the remainder of the year. It is hot and damp from March until the end of September, and temperate for the remainder of the year, in the Telingana districts. Three-quarters of the rainfall occurs between June and September, and the balance in October and November ; it varies between 25 inches in the south-west to 50 inches in the north-east.

Black cotton soil, similar to that found in the adjacent British territory, prevails for the most part in the cotton-growing areas ; although in the Telingana districts it is not so rich as in the north, and cotton is often grown on lighter soils. The cultural methods in vogue are likewise similar to those obtaining in the adjacent British districts.

Varieties of Cotton Grown.—In the north of the State, and extending as far south as Gulbarga, cotton known by the trade name of “Barsi and Nagar” is grown. It comprises a mixture of varieties similar to that found in the Central Provinces, but *bani*, *G. indicum*, is present in a greater proportion, and *buri*, *G. hirsutum*, takes the place of Upland Georgia. *Buri* predominates and is grown pure over large areas in the Adilabad, Nizamabad, and Karimnagar districts in the north-east. The Agricultural Department has been mainly instrumental in extending the cultivation of *bani* in a pure state over large areas of the Parbhani and Nander districts farther west. This variety also forms a high proportion of the mixture of varieties grown round Jalna in the Aurangabad district, in the Osmansabad district, and in the northern part of the Gulbarga district. *Bani* was formerly the true cotton of the Mahratwarra country, but it suffered rapid deterioration through admixture of Berar seed. The action taken by the Agricultural Department to restore it to something approaching to its original standard, saved it from rapidly disappearing altogether, or from becoming a minor constituent in a mixture of varieties, except in districts remote from the railway. One of the beneficent results of the distribution of pure seed of *bani* has been to increase the ginning percentage to 29, as against the previous average percentage of 25 to 26. The Agricultural Department has a cotton farm for work on *bani* at Parbhani, and another at Mahbubnagar for work on Cambodiaa.

MADRAS

Exclusive of the Native States, the area of the Madras Presidency is about 91,947,000 acres. Some 34,450,000 acres are cropped, of which 2,280,000 acres are under cotton. There are also 24,000 acres under cotton in the Native States. The percentage of the area under cotton to the total area under cotton in India, and to the total cropped area in Madras, is 10·2 and 6·6 respectively. These percentages are exceeded by the Central Provinces and Berar, Bombay and Hyderabad; still the Madras cotton industry is of considerable importance on account of the circumstance that, with the possible exception of the Punjab, it produces

more cotton of a staple suitable for the Lancashire trade than any other part of India. Of a total crop of 500,000 bales, about one half can be placed in this category, while, with the possible exception of Coconadas cotton, the balance is long staple cotton as defined by the Bombay cotton trade. For the purposes of the Lancashire mills, what is designated as "commercial inch" cotton is regarded as long staple, although its actual measurement is less than an inch but is over $\frac{7}{8}$ inch. The Bombay cotton trade looks upon any cotton with an actual measurement of $\frac{3}{4}$ inch and over as long staple.

Cotton Areas, Climate, and Soils.—The Madras cotton-growing areas may be separated into three, fairly well-defined, divisions: (1) The Deccan tableland, which comprises the districts of Bellary, Kurnool, Anantapur, and Cuddapah, where the cotton varieties known as Westerns and Northerns are grown. (2) The area that produces the cotton known in the trade as Coconadas, which lies along the east coast of the Peninsula, and includes the districts of Godavari, Nellore, Kistna, and Guntur, of which the last mentioned is much the most important, and (3) that which comprises the southern districts of Tinnevely, Ramnad, Coimbatore, Madura, and Trichinopoly. Cambodia cotton is grown on the red soils and is the predominating variety in Coimbatore, where Uppam is the only native cotton grown on the black soils. In the other districts, Karunganni and Uppam, either mixed or pure are grown on the black soils.

Tinnevely has the highest mean temperature, which is not so much owing to extreme heat in the summer as to the lack of moderate coolness in the cold season. Great heat obtains in the Deccan tableland from March until May, but the remainder of the year is fairly temperate. In the cotton-growing districts the average rainfall varies from 22·66 inches in Bellary to 39·40 inches in Godavari. In the Deccan and east-coast districts, the bulk of the rainfall is received from the south-west monsoon, but all districts get rain both from this and from the north-east monsoon as well. The position is reversed in the south, for Tinnevely gets only 3·10 inches in the south-west monsoon months and 17·79 inches from the north-east monsoon. Bellary and Coimbatore, with a

rainfall of 22.66 and 26.16 inches respectively, are the two driest districts in the presidency.

Most of the native cotton is grown on a retentive, black cotton soil, which is often saline and shallow, but it is also grown on red, loamy soils in the Deccan districts. A large proportion of the Cambodia cotton is grown under well irrigation; otherwise cotton is a "dry crop" and is entirely dependent on rainfall. The unirrigated soils are generally deficient in humus, phosphoric acid, nitrogen, and, in the case of the red soils, lime. In these circumstances, it is not surprising that the yield of cotton per acre, both with and without irrigation, is lower than in any other province in India.

Varieties of Cotton Grown.—Northern cotton is a mixture of *G. herbaceum madraspatna* and *G. indicum*. A large proportion of the lint is red tinted and is regarded as of superior quality; the staple length is $\frac{7}{8}$ inch and the ginning percentage is 27. Western cotton is almost entirely composed of *G. herbaceum*, but it contains traces of *G. indicum*; the staple length is $\frac{3}{4}$ inch and the ginning percentage is 25. Cambodia and Dharwar American, *G. hirsutum*, and *G. neglectum* are also found in some of the Northern and Western areas.

The Agricultural Department's work at the Bellary and Hagari farms has been mainly devoted to Western cotton, while that at the Nandyal farm, in the Kurnool district, has been mainly devoted to Northern cotton. Seed selected in bulk and distributed in the Bellary district was found to be in no way superior to the local varieties. The results at Nandyal were more encouraging, for the selected cotton was superior both in yield and ginning percentage, and it became known as Sircar cotton. Later a selected strain was developed both at Hagari and Nandyal; Hagari No. 1 had a ginning percentage of 27.3 as against that of 25 for the local variety, the yield was equal to the local variety but the length of the staple was superior. The ginning percentage of the variety distributed from Nandyal, known as Sircar No. 2, was 30 as against that of 25 for the local variety; the yield was equal to that of the local variety but it was superior in every other respect. Neither strain has fulfilled expectations. It has therefore been proposed to replace

Hagari No. 1, in the Westerns area, with a new type known as No. 25, and to replace Sircar No. 2, in the Northern area, with a strain of *G. indicum* known as No. 14, which has a staple fully 1 inch long but, while the yield is good, the ginning percentage is only 25.

Coconadas cotton is a mixture of many types, of which the predominating ones are *G. obtusifolium* Coconada and *G. indicum* yerrapati. Most of the lint has a reddish tint with a staple of $\frac{5}{8}$ to $\frac{7}{8}$ inch, and a ginning percentage of 23.

Until 1907 Tinnevely cotton consisted of a mixture of Karunganni, *G. indicum*, and Uppam, *G. herbaceum*. Superior strains of the former, distinguished as Company cotton, have been developed by the Agricultural Department with a staple of $\frac{7}{8}$ inch and a ginning percentage of 32, which are now grown on about one-half of the Tinnevely area. In other parts of this area, Karunganni is gradually replacing Uppam, but the latter continues to be grown in the Coimbatore and Trichinopoly districts under the trade name of Salems.

The mixture of Uppam and Karunganni has a staple of $\frac{3}{4}$ to $\frac{7}{8}$ inch and a ginning percentage of 27, but pure Uppam has a staple of $\frac{3}{4}$ inch and a ginning percentage of 25. Cambodia is grown without irrigation in the Coimbatore district, where it is replacing Uppam. In the Coimbatore and Trichinopoly districts, a perennial indigenous variety known as Nadan, *G. obtusifolium*, with a staple of $\frac{3}{4}$ to $\frac{7}{8}$ inch and a ginning percentage of 23, is grown on about 20,000 acres. Bourbon, *G. purpurascens*, an exotic perennial cotton, is grown on about 10,000 acres in the Coimbatore district; it has a staple of 1 inch and a ginning percentage of 25.

As regards acreage, yield, and length of staple, Cambodia is the most important cotton grown in Madras. Under irrigation it has a staple of $\frac{3}{4}$ to $1\frac{1}{8}$ inch, while without irrigation its staple is $\frac{5}{8}$ to $\frac{7}{8}$ inch; its ginning percentage is 33. It is known on the English market as "Tinnevely American". About one-third of the Cambodia crop is grown under irrigation, but this is superior in every respect to the unirrigated portion of the crop, and the total yield from the irrigated and unirrigated areas is approximately equal. The possibility of developing different types of Cambodia adapted to irrigated and non-irrigated conditions respectively, appears to be well worth investigation. The success of the existing type

under irrigation has led to its being grown on unirrigated black soils, which are not suitable for it and where it consequently gives poorer results.

Numerous experiments, dating as far back as 1790, have been conducted with various exotic cottons in Madras. Bourbon is the only surviving relic of the early experiments. Except in the case of Cambodia, of recent years, the Agricultural Department has confined its attention to the improvement of indigenous cottons. In 1919 Cambodia strain No. 2 yielded 2168 lb. of seed cotton per acre under test at Coimbatore. During the season 1920-21 seed of improved cotton varieties distributed by the Agricultural Department was planted on 68,500 acres.

Cultivation.—In the Northern and Western areas, as well as on the black soils of Madura, Tinnevely, and Ramnad, good cotton cultivation obtains, and the same remark applies to irrigated Cambodia cotton. The seed of Northern and Western cottons is always sown with a drill. Northern cotton is generally sown mixed with horse gram, *Dolichos biflorus*, in August and September on black soils, and the next season it is followed by a mixture of *juar*, *Sorghum vulgare*, and green gram, *Phaseolus mungo*. It is sown a little earlier on red soils, but in this case it is usually mixed with Italian millet, *Setaria italica*, one row of cotton being sown to two rows of millet. The succeeding crop is also *juar* mixed with one or more pulses. Western cotton is sown on black soils in July-August, and on red soils in August-September. The rotation is similar to that of the Northern.

On black soils the picking of both Northern and Western takes place from February to April. On red soils the picking of Western begins in October, but, as the crop matures during the north-east monsoon, the lint is usually discoloured. Picking is not carefully practised; the seed cotton therefore contains much leaf and dirt, and mill reports show an average blow room loss of 18 per cent. In the southern districts the crop is much later than in other parts of India; it is sown in October and picking commences in February and continues until July. Except that sowing is done broadcast on the black soils of Madura, Ramnad, and Tinnevely, the cultural methods in these districts are satisfactory. Moderate

success has attended the efforts of the Agricultural Department to substitute the method of sowing in lines for broadcasting, and this has permitted better interculture with the bullock hoe. As regards crop rotation, cotton usually follows a cereal; in the south this is generally *kumbu* or *bajra*, *Pennisetum typhoideum*, and in the north *varagu*, *Paspalum scrobiculatum*. Cotton is commonly grown mixed with Coriander. Cattle manure is the principal fertiliser in use, and with this is composted tank silt, ashes, vegetable and other refuse. It is always applied to the cereal crop. Less attention is given to crop rotation on the black soils in the Coimbatore district, and cotton is grown year after year without fertiliser. In Trichinopoly, cotton, pulses, and cereals are sown together broadcast. Irrigated Cambodia cotton is generally fertilised with cattle manure and tank silt, but it receives less attention when it is grown as an unirrigated crop, and this neglect is reflected by a shorter staple. In certain cases, it is left in the ground for two or three years; consequently the crop is small after the first year, and the lint deteriorates in length and strength, while the plants serve as a host for insect and other pests. It is proposed to check this practice by legislation.

The Agricultural Department manufactures, and sells at low rates, implements adapted for sowing and interculture. It is considered that this procedure could be usefully supplemented by the employment of power ploughs, on a co-operative basis, and more particularly where the land is badly infested with deeply-rooted weeds.

Seed Distribution.—In the Bellary, Kurnool, and Tinnevely districts, pure seed is grown for the Agricultural Department on considerable areas. In the Tinnevely area, organisations have been developed for the purpose of seed distribution. In 1916–17, 362 ryots¹ in 71 villages formed an association with the object of getting their cotton ginned and sold. Seed Unions, operating under approved rules, were constituted in six villages. A Union comprises five or six ryots, who undertake to plant the whole of their cotton land with the selected seed provided by the Agricultural Department, also to gin the cotton and to sell the lint under the Department's supervision and to conserve the seed for sale in the succeeding

¹ Ryot = tenant farmer.

of these the most promising as regards yield are *G. indicum Mollisoni* and *G. neglectum roseum*.

Cultivation.—Irrigated cotton is usually sown in April, and in the south-west of the province it continues up to the end of June. Unirrigated cotton is sown at the end of June. The seed is either scattered or dropped by hand behind the plough. For American cotton in the Canal Colonies, sowing in lines has been introduced and this practice is gaining in favour. Previous to sowing the land is levelled and ploughed, and the best growers plough two or three times. Growing cotton receives little cultivation. Two or three months subsequent to sowing, the native plough is run through the crop; this destroys weeds and, especially in broadcasted cotton, some cotton plants as well. The beneficial effects of harrowing the young crop is beginning to be appreciated. As the area under cotton is small as compared with that under other crops, cotton seldom follows cotton in the rotation, but is planted after *toria*, *Brassica campestris*, maize, gram, sugar-cane, and wheat. It is considered undesirable for cotton to follow wheat, as sufficient time is not available between the crops to allow of proper land preparation prior to cotton sowing.

Cotton picking begins in September, and from five to seven pickings are usually made. The picking of American cotton continues until December. Pickers are generally paid in kind, and the cost works out at about 10 per cent of the crop. The average yield varies per acre from 80 lb. of lint on unirrigated land to 160 lb. under irrigation. With the exception of Madras and the Central Provinces, this is the lowest yield of any other province in India. Much good could be done in improving the yield by the general adoption of row planting and interculture.

Auctions.—The crop is sold as seed cotton either to the ginnery owners, who are also generally cotton merchants as well, or through brokers to the export merchants. Originally the cotton grown under the supervision of the Agricultural Department was sold by private treaty. Auction sales, supervised by the Department, have been instituted so as to secure for the American cotton a suitable premium over the native kinds. As the Department collects the seed cotton and guarantees its purity, much higher premiums

have been forthcoming than would otherwise be the case. Latterly private auctions have been successfully conducted.

Seed Distribution.—The best seed cotton sold at the auctions is received by the Department, who supervise its ginning and distribute the seed to agents for sale on commission. The growers willingly pay a higher price for seed of this description. In the Canal Colonies there are a number of large landowners who willingly co-operate with the Department in the distribution of pure seed. A continuous supply of pure seed is ensured by planting 10 acres of selected seed on the Lyallpur farm, which produces about 30 cwt. of seed. About 4 cwt. are sent to the Government seed farm at Montgomery, and the balance is distributed to the large landowners previously referred to, and to farmers who agree to return the seed produced to the Department. So far, the need for special seed farms to raise American cotton has not arisen in the Punjab, for the large landowners are able to produce all the seed likely to be required in the near future. In the event of the extension of the cultivation of American cotton to new areas in the province, or if superior strains of native cotton be developed, seed farms will be necessary for the Department to retain control of the seed. It is considered that the work connected with the auction sales, and also with seed distribution, might now usefully devolve on organisations of large landowners, either in the form of co-operative societies or otherwise, but that they must work in close touch with the Department, so that it may control seed distribution.

Possible Extension of Irrigated Cotton.—Any large extension of American cotton cultivation is almost entirely dependent upon an increase of irrigation facilities, for this cotton requires a much longer growing season than the native varieties. Various irrigation projects under construction or consideration are therefore of importance in this connection. They comprise: 1. The Sutlej River Projects, which would give an additional 325,000 acres of cotton, including 70,000 acres of American cotton; (2) The Haveli Project, which would give 100,000 acres, including 70,000 acres of American cotton; and (3) The Sind Sagar Doab Project, which would give 100,000 acres, including 60,000 acres of American cotton.

Exceptionally favourable prospects are stated to exist for more extensive cotton cultivation in the Bahawalpur State, which is situated in the south-west corner of the Punjab. The rainfall is very small, only 6 inches per annum, some years being practically rainless. It is understood that the Bahawalpur Darbar have projects under consideration for the construction of perennial canals, which would place 1,292,410 acres under irrigation.

The British Cotton Growing Association's Estate. — A recent development of great interest is an estate opened by the British Cotton Growing Association at Khanewal. When the Punjab Government were colonising the Lower Bari Doab tract, they allotted certain extensive grants of land on lease for specific purposes, and one of 7300 acres was made to the Association, with the object of encouraging long staple cotton cultivation, testing varieties, and establishing a buying agency for long staple cotton.

The estate is worked under the tenant system and *batai*; i.e. the tenant gets half the produce and the Association half; the water rate and land revenue and taxes being paid half by the tenant and half by the Association. *Batai* is not a new development, but is a system which has long been recognised and is well understood in the Punjab.

A feature of the estate is the well-planned villages, with trees and wells, that have been established for the tenants and labourers, whose well-being is always an essential factor in successful estate management.

The manager of the estate was formerly a member of the staff of the Lyallpur Agricultural College, and his five assistants are graduates or diplomates of this college, while an honours graduate in botany has been also engaged, and it is hoped to utilise his services to supplement and assist the work of the Agricultural Department in establishing superior varieties of cotton.

Cotton Yields. — In the season 1922-23, 1300 acres of American cotton were grown with an average yield of 988 lb. of seed cotton per acre in 4 F and 289 F types, and 864 lb. in the 285 F type. The *desi* or native cotton yielded 1317 lb. of seed cotton per acre, yet the 4 F type gave the best financial return by about 15s. per acre. In the 1923-24 season, 1400 acres of American cotton gave an average yield of

1152 lb. of seed cotton per acre, while 600 acres of *desi* cotton gave an average yield of 1243 lb. of seed cotton per acre. These results have not been attained by any other estate, large or small, in the Punjab. The 285 F and 289 F cottons found a ready market in Manchester, and the best 285 F cotton was valued at fifty points over American middling cotton.

Cultural Methods.—The land prepared for cotton is given what is known as double *rauni*, i.e. two waterings before sowing, which secures good tilth and a reserve of subsoil water. No further irrigation is given for from six to ten weeks after sowing, so as to encourage deep-rooting to ensure better resistance to drought should there be a shortage of water later on in the season.

American cotton is shown in lines 3 feet apart, and *desi* cotton in lines 2 feet apart. Interculture is practised on from four to six occasions, and usually after irrigation. For this operation the “bar harrow” is much favoured.

The Association’s staff issue instructions as to what operations are to be performed, and what crops require watering; this procedure is appreciated, and taken full advantage of, by the tenants, who appoint headmen from among themselves to assist the staff.

Experiments are being conducted in both tractor and steam power cultivation, and the results should be of great assistance in connection with the large tracts that will shortly be coming under cultivation for the first time in the Punjab and Sind. Moreover, it is probable that work of this character, during the first years of colonisation, will materially reduce the estimated costs with regard to such canals as the Sutlej Valley in the Punjab and the Sukkur Barrage in Sind.

The work of the Agricultural Department is assisted by large scale tests of varieties grown alongside one another, of which the yields are recorded separately. In this manner the new varieties produced by the Agricultural Department can be expeditiously and satisfactorily tested under ordinary field conditions, and remote from Government farms.

Great care is devoted to the supply of pure seed. In the 1923-24 season, sufficient seed to plant 100,000 acres of cotton was supplied to the Agricultural Department, besides

a large quantity sold direct to cultivators. In the same manner with regard to wheat, sufficient seed for all requirements is supplied to tenants at market rates.

Buying Agency.—The Association has established its own buying agency so as to facilitate the securing of good prices for the tenants' cotton, and a premium over the ordinary market qualities is always obtained. Other large growers who can produce cotton of uniform quality are also enabled to sell their crops to the Association at a premium.

It is considered that more estates of this nature might be developed with considerable advantage in other parts of the Empire, especially in tropical Africa, for they assist the Government in developing the land, build up a strong unofficial section of the population which is in close touch with the native farmers, aid the Agricultural Department in solving various problems associated with scientific agriculture, function as model farms for local farmers, raise funds for agricultural development which Government cannot usually carry out, encourage co-operation in trading among landlords and tenants, and generally improve the conditions of native farmers by ensuring for them a fair return for their labours.

Progress in Cotton Production.—The forecast of the Punjab cotton crop for the year 1924 shows the area under cotton to be in excess of the previous year by 30 per cent, and of the quinquennial and decennial averages by 44 and 52 per cent respectively. Of this area 934,200 acres were under American cotton, and 1,339,400 acres under *desi* cotton. The acreage under American cotton constitutes a record. The total estimated out-turn in British Districts is estimated at 354,700 bales of American and 422,900 bales of *desi*. The total yield is 36 per cent more than the previous year, and averages .34 bale per acre sown. The yield in the Native States is estimated at 115,000 bales, or 91 per cent higher than in the previous year.

CENTRAL INDIA

The area under cotton in the Native States, which comprise the Central Indian Agency, is 1,335,000 acres, or 6 per cent of the total area under cotton in India. The principal

contributing States are Indore with 450,000 acres, Gwalior with 380,000 acres, and Bhopal with 73,000 acres. The total cropped area of the Agency is about 13,000,000 acres, of which that under cotton represents approximately 10 per cent.

The principal cotton-growing region is situated in the southern section of the western portion of the Agency, which again lends itself to separation into two natural divisions. The larger of these divisions lies on the Malwa plateau, while Nimar, the smaller, lies south of Malwa below the Vindhyan range.

The rainfall of the cotton-growing districts is about 30 inches, nearly all of which is received from the south-west monsoon.

On the plateau black soil formed by the disintegration of the Deccan trap prevails, while in the Nimar region lighter soils predominate and these render irrigation necessary.

Here again the principal cotton consists of a mixture of varieties resembling that found in the Central Provinces. In the mixture grown on the plateau, the proportion of *G. neglectum malvense* is high, and it is considered probable that it is indigenous to this region. Its staple is $\frac{3}{4}$ to $\frac{7}{8}$ inch, but its ginning percentage is only 25. In a pure state this variety is grown on about 112,000 acres; unfortunately very little of the crop reaches the market in an unadulterated condition. It is probable that the ginning percentage, as well as the yield of this variety, could be considerably improved by careful selection work; an organisation is also required to ensure its being marketed in a pure state.

Georgia Upland cotton has been successful under irrigation on lands where poppy was previously cultivated. Moderate success has also been attained with Cambodia cotton under similar conditions.

In the Gwalior State the licensing of ginneries has been enforced, and a system now obtains by which bales of cotton produced in the vicinity of Ujjain are stamped accordingly, while inferior cotton that is brought into Ujjain from other districts for re-export to Bombay or elsewhere as Ujjain cotton is stamped as "Ujjain mixed". In both cases the name of the factory where the cotton has been pressed is also stamped on the bales.

Cotton is usually planted in Central India after the first

rainfall of the monsoon, but it has been found in the investigations at Bhopal and Ratlam that cotton planted under irrigation before the monsoon gives a heavier yield. In view of the success already attained with Upland Georgia and Cambodia under irrigation, the question of extending well irrigation facilities is important.

UNITED PROVINCES

The area of the United Provinces is 68,303,707 acres ; the cropped area is 35,680,000 acres, of which 1,239,000 acres are devoted to cotton. The percentage of the area under cotton to the total cropped area is thus 3·5, and 5·6 of the total area under cotton in India. There are in addition about 13,000 acres under cotton in the Native States of the province. Nearly one-third of the cotton crop is grown under irrigation. The principal cotton-growing districts are situated in the west, the most important being Bulandshahr, Muttra, Aligarh, and Agra, but cotton is grown throughout the United Provinces.

The cotton-growing season is characterised by its relative brevity, aggravated by the nature of the rainfall. During the middle period the rainfall is so heavy as to cause the soil to be more or less constantly water-logged ; a condition which definitely checks the growth of the plants. The monsoon starts at the end of June or early in July and ends in September ; the rainfall varies from 21 to 40 inches. In the principal cotton-growing districts, the temperature is higher, both in the dry season and during the monsoon, and the rainfall is smaller than that of the more easterly stations. The soil of these districts consists principally of the alluvium of the Gangetic Plain.

Varieties of Cotton Grown.—Nearly all the cotton of the United Provinces is sold under the commercial name of Bengals ; ordinary Bengals having a staple of $\frac{3}{8}$ to $\frac{1}{2}$ inch and fine Bengals $\frac{1}{2}$ to $\frac{5}{8}$ inch. It comprises a mixture of the following indigenous varieties : *G. indicum* (staple $\frac{3}{4}$ inch, ginning percentage 32), *G. i. Mollisoni* (staple $\frac{3}{8}$ to $\frac{1}{2}$ inch, ginning percentage 40), *G. n. malvense* (staple $\frac{5}{8}$ inch, ginning percentage 30), *G. n. verum* (staple $\frac{1}{2}$ to $\frac{5}{8}$ inch, ginning percentage 38), *G. n. bengalense* (staple $\frac{5}{8}$ to $\frac{3}{4}$ inch, ginning percentage 33), *G. n. roseum* (staple $\frac{3}{8}$ inch, ginning percentage

38), and *G. n. cutchicum* (staple $\frac{3}{8}$ inch, ginning percentage 36). The first two mentioned are only occasionally present, but the others are ubiquitous throughout the province.

The early attempts to cultivate American cotton in the United Provinces were not successful, but further trials instituted at Cawnpore in 1870 established the acclimatised variety known as Cawnpore American. The Agricultural Department has assisted with the ginning and handling of this cotton, and also in securing to the growers a premium for it over the native cotton. There has been a considerable increase in the demand for seed of this variety, and in 1921 over 8000 acres were planted with it. In connection with this cotton, special attention is being devoted to the evolution of suitable varieties of a rough-leaved type, for experience has shown that they are healthier and less susceptible to insect attack than the smooth-leaved types. A set of pure line selections has been obtained superior, in yield, ginning percentage, and uniformity of staple, to the unselected field crop. One of these, C.A. 9, has continued to yield well, and a commercial report on the lint states : it spun 28's and 30's ring twist, also " the cotton was found to spin fairly well and the strength was not much different from that of good $1\frac{1}{8}$ inch Texas (cotton). The yarn was not quite so clean as that spun from the usual quality of Texas good middling cotton, but altogether we should consider that there should be a fair demand for this type of cotton." The ordinary Cawnpore American cotton is being steadily replaced by this selection. In 1920 it was planted on 1000 acres ; sufficient seed should therefore soon be available to replace the original type. Provided it is sown early with irrigation, Cawnpore American cotton has been proved to be equal in average yield to native cotton grown under similarly favourable conditions. Further, it realises a much better price than native cotton, and is profitable to the grower if adequate marketing arrangements obtain.

Work by Dr. Martin Leake, of the Agricultural Department, in connection with the improvement of indigenous cottons, by crossing and selection on Mendelian lines, has resulted in the isolation of varieties with a fair length of staple and a high ginning percentage. Of these, a variety designated as K 22 with a staple of $\frac{3}{4}$ inch and ginning percentage 37, and another,

K 28 with a staple of $\frac{7}{8}$ inch and ginning percentage 37 to 40, are showing great promise. The former has been grown on Government farms and distributed to farmers in the neighbourhood.

The indigenous cottons have also been studied by Parr, of the Agricultural Department, who found that the Aligarh white-flowered cotton, *G. neglectum*, is the most profitable variety to grow, for it yields better than the local mixture. It has a ginning percentage of 38 to 39 as compared with 33 for the latter, and produces superior quality and whiter lint. It is, however, regarded with disfavour by the trade because the staple is barely $\frac{3}{4}$ inch. Consequently it is considered inadvisable to promote the spread of this variety until it has been definitely established that no superior variety of *G. neglectum* can be discovered which will prove equally profitable to the grower. Possibly the ginning percentage could be improved of one or more of the other varieties of *neglectum*, which have a longer staple than that of the Aligarh white-flowered cotton. It is thought that the United Provinces are not generally adapted to cotton of more than $\frac{3}{4}$ inch staple, but a considerable improvement would be effected if cotton with a uniform staple of $\frac{5}{8}$ inch were substituted for the existing mixture. That improvements along these lines have been made is shown by the Government reports to the effect that, during the season 1920–21, 200,000 acres were planted with improved varieties of cotton; still, in the season 1922–23, the hardy, high ginning, short staple cottons proved most remunerative. The cultivation of Cawnpore American cotton was largely discontinued because of the lack of irrigation facilities.

Irrigation and Cultivation.—The extension of the cultivation of American cotton is restricted, because the canal irrigation facilities rarely supply the whole village, so that only a portion of the village area can be planted with American cotton. Consequently American and native cottons are found growing together side by side to the imminent danger of mixture of both seed and lint. American cotton grown under wells, worked by bullock power, involves the use of a great amount of water for preliminary cultivation in the hot weather, and a consequent strain on the cattle; it is therefore unlikely that this practice will be very largely extended.

Concessions are granted in respect of water supply on certain channels, with the view to encourage more extended cultivation of American cotton, and it is suggested that these concessions should be continued until their effect is definitely known. Provided a sufficiently high premium for American cotton can be assured, an area of 100,000 acres on the Ganges canals, and 35,000 acres on the Agra canal, may be anticipated. Irrigation is entirely dependent on wells in many parts of the province. There are over $1\frac{1}{2}$ million wells in use irrigating an area of 6 million acres, or about two and a half times the area irrigated by canals. So that ample scope is afforded for the development of pump irrigation. Of recent years, tube wells and pumps worked by power have been successfully installed by the Agricultural Department. The construction of the great Sarda Canal is in active progress, and of the area commanded about $1\frac{3}{4}$ million acres will be irrigated.

Two or three ploughings are generally given in preparing the land for planting. The seed is sown broadcast, and, except where irrigation is practised, as it is not possible for the soil to be worked until rain falls, the seed has to be sown immediately afterwards because of the shortness of the season. Cotton is generally weeded once by hand.

A mixture of barley and peas is often grown after irrigated native cotton. American cotton is only grown under canal irrigation, but, because of its longer growing season, it is not practicable for barley and peas to follow it, and this presents one of the difficulties with which American cotton has to contend.

The general adoption of line planting, in place of broadcasting, and interculture should be encouraged. The possibility of growing a fodder crop with cotton in September and October is also worthy of consideration; this practice is in general use in the Punjab, Sind, and the North-west Frontier Province, where berseem, *shaftal* and *senji*, *Melilotus indica*, are the fodder crops most commonly grown.

Markets.—As regards markets, the grower of native cotton is very much in the hands of the middleman. As communications are good, it is most probable that properly regulated markets on the Berar system could be usefully established. The Agricultural Department buys the seed cotton of the Cawnpore American variety, gins it, and makes

arrangements for the disposal of the lint; for the Cawnpore mills are unwilling to buy the crop in the form of seed cotton. As the area under this variety is so scattered, it will be necessary for this procedure to continue until the area under cultivation approximates 20,000 acres, and a crop of about 7000 bales is produced, unless this work can be undertaken by an unofficial agency. In view of the success that has attended the Government auctions of seed cotton in the Punjab, it is suggested that a similar scheme could be advantageously instituted in the United Provinces. Should the area under Cawnpore American cotton be largely extended, or superior native cotton varieties be successfully introduced, the number and area of seed farms will have to be greatly increased, to permit the Agricultural Department to retain control over seed distribution.

THE NORTH-WEST FRONTIER PROVINCE

The area of this province is 8,437,733 acres. The cultivated area is 2,308,000 acres, of which 46,000 acres are under cotton; about 17,000 acres being grown under irrigation. The percentage of the area under cotton to the total cropped area is 2.0, and to the total area under cotton in India, 0.2.

Most of the cotton crop is produced in the Peshawar and Dera Ismail Khan districts. In the latter, the climate and soil closely resemble those of the contiguous districts of the Punjab. In the principal cotton areas of the Peshawar district, the soil is thin and poor. As these areas lie above the Peshawar Valley, they escape the high humidity and frost that are characteristics of the climate of the valley.

The mixture of cotton varieties grown resembles that of the Punjab; the predominating types being *G. n. verum* and *G. n. malvense*. The ginning percentage of the mixture is only 25 to 26. The quality of the cotton is superior to the native cotton of the Punjab, and probably the ginning percentage could be much improved by careful selection work. On the Government farm at Peshawar, American cotton has been grown with indifferent success, but better results have been obtained on small areas in the Dera Ismail Khan district; the need of an assured water supply has, however, prevented further developments.

The possibilities of longer staple cotton production depend, to a large extent, on irrigation facilities. An extension of the cotton-growing area is anticipated in that portion of the Peshawar district which is irrigated by the Upper Swat River Canal. This canal was opened in 1914-15, and, when fully developed, it will have a capacity for irrigating 348,987 acres. The area which it serves appears to be well adapted to native cotton production. Further extension of cotton growing is also offered in that portion of the Dera Ismail Khan district which is irrigated by the Paharpur Inundation Canal. It is proposed to make this canal perennial by constructing a barrage across the Bilot Creek, from which it takes off. It is estimated that the execution of this project will make 12,000 acres available for American cotton.

SIND

For administrative purposes, Sind forms part of the Bombay Presidency, but the cotton problems of Sind are entirely different from those of the rest of the presidency. The area of Sind, excluding the Native States, is 30,098,076 acres. The net area actually cropped is 4,138,000 acres; with the exception of 50,000 acres, all this is irrigated, which affords an excellent illustration of Sind's dependence on the waters of the Indus. There are about 5,954,000 acres of culturable waste and 5,164,000 acres of current fallows. The area under cotton is approximately 268,000 acres, which is 6.5 per cent of the net cropped area and 1.2 per cent of the total area under cotton in India. In addition, 7000 acres of cotton are grown in the Native State of Khairpur. The whole of the cotton crop is grown under irrigation.

The cotton-growing areas are principally concentrated on the left bank of the Indus, in the districts of Nawabshah, Thar and Parkar, and Hyderabad. The province is practically rainless, for it only receives 2 inches of rain in July and August, and rather less than this amount during the remainder of the year. Great fluctuations of temperature occur. During the cool season, October to March, the days are cool and pleasant, but at night the temperature frequently falls below freezing point. The dry heat is intense in the hot season, and reaches a maximum temperature of 126° F. at Jacobabad. The soil

is an alluvial loam, similar to that of the Punjab, but stiffer in texture ; in many districts it closely resembles that of the Egyptian Delta, and the climatic conditions likewise resemble those that obtain in the latter country.

Varieties of Cotton grown.—A mixture of native cottons is grown similar to that found in the Punjab, with the addition of *G. n. cutchicum* and the exception of *G. sanguineum*. The cotton is rougher, stronger, and whiter than that of the Punjab and is more prolific ; in favourable seasons, 800 lb. of seed cotton per acre are obtained as compared with 520 lb. on irrigated land in the Punjab. The length of the staple is $\frac{3}{8}$ to $\frac{5}{8}$ inch and the ginning percentage is 35. Small areas are planted with American cotton, and Egyptian cotton is grown on the Government farms.

Cultivation and Irrigation.—The bulk of the land is in the hands of large landowners, who let it out in blocks to the farmers. As the latter are yearly tenants, they have little interest in the land. It is therefore not surprising that the cultural methods in vogue are of a low degree. The landowner provides the seed, ploughs, cattle, and labour ; he divides the crop, and, after deducting the value of the seed advanced, pays the land assessment out of his share of it. Cultural implements are crude and crop rotation is unknown. A clumsy native plough is in use and a heavy log of wood serves for a harrow. The immemorial practice of fallowing two-thirds of the land each year is an important factor that influences the system of cultivation. The Standing Orders of the Bombay Government recognise the practice, for assessment is only payable on occupied land for the years in which it is cultivated wholly or in part, unless no assessment has been paid for the land for four consecutive years, when assessment is payable on it in the fifth year whether it is cultivated or not. Scarcity of water, a scanty population, and an abundance of land are also factors contributory to the low standard of agriculture.

Much success has been obtained with berseem cultivation on the Government farms, the crops being fully as good as those raised in Egypt ; this indicates that it would form a most suitable rotation crop with cotton in Sind, but the successful cultivation of this crop is only feasible with a perennial water supply.

Experiments with Egyptian and American varieties of cotton in Sind date back as far as 1846, and it has been amply demonstrated that they can be successfully grown. Unfortunately, however, attempts to grow them on a commercial scale have failed, principally owing to the unsatisfactory irrigation facilities available. Other factors contributory to this result were inferior cultural methods, the importation of new seed instead of developing acclimatised varieties, and the failure of the growers to secure the full value of their cotton. The soil and climate are admirably adapted for the successful cultivation of long staple cotton, and water only is needed at the right time, and in sufficient quantity, to make Sind the most flourishing long staple cotton-producing area in India.

The Sukkur Barrage project is now under construction, with the view to supply an ample and steady water supply for large areas in Sind, including practically the whole region in which cotton is now grown. When this is completed, it is anticipated that some 6 million acres will be added to the 28 million acres which the Government irrigation works already protect in India. It provides for a barrage across the Indus adjacent to the Sukkur-Rohri Gorge, a canal, to be called the Rohri-Hyderabad Canal, from the left bank of the Indus, to take over the irrigation in the Nasrat and Hyderabad districts, and also irrigate a portion of the area served by the Fuleli Canal, and a canal from the right bank of the Indus to take over the irrigation in the Ghar and Western Nara Canals districts. In addition, it provides for improvements to the Jamrao Canal and the canals in the Eastern Nara Canals district. The construction of the Sukkur Barrage is expected to convert 400,000 acres of land into a condition suitable for the cultivation of long staple cotton, comprised as follows : Rohri-Hyderabad Canal, 250,000 acres ; Jamrao Canal, 100,000 acres ; Eastern Nara Canals, 50,000 acres. It is proposed to provide for an intensity of 50 per cent, or that one-half of the area will be irrigated annually. Under existing conditions, the intensity is only $33\frac{1}{3}$ per cent, and it has been suggested that the possibility of enlarging the canals to carry supplies sufficient for an intensity of 75 per cent should be considered. Besides providing this large area of land for long staple cotton cultivation, it is estimated that the satisfactory completion of the Sukkur Barrage project

would transform some $5\frac{1}{2}$ million acres of culturable land, which are at present poorly cultivated and sparsely populated, into one of the richest and most productive regions in India. It would substitute large perennial canals for a network of small inundation canals, and convert irrigation by lift into irrigation by flow over large areas.

Recommendations have been made to the effect that large capitalist grants of land under the perennial canals should be made, of from 2000 to 5000 acres in extent. For they would be of assistance to small growers in the marketing of their produce, and be utilised as pure seed farms, besides facilitating the development of the irrigable area. Further, that some of these grants should be allocated on the condition that the land is cultivated by steam power, so as to bring about more speedy development and reduce the amount of labour required.

There appears to be no prospect of cultivating either Egyptian or American cotton on an extensive scale in Sind, unless an irrigation scheme of this nature is carried out. Failing this, the cultivation of these cottons will have to be abandoned, and attention will have to be concentrated on developing strains of native cotton of longer staple and higher ginning percentage than those at present grown.

BURMA

The area of Burma, exclusive of the Native States, is over 109 million acres. The cropped area is 14,278,000 acres, of which a quarter of a million acres are under cotton. The percentage of the area under cotton to the total cropped area is 1.8, and to the total area under cotton in India, 1.1.

There are five important cotton-growing districts : Thayetmyo, Sagaing, Lower Chindwin, Meiktila, and Myingyan. They are all situated in what is known as the "dry zone", where the rainfall varies from 25 inches in Myingyan to 37 inches in Thayetmyo.

The rainy season lasts from the third week in May till the third week in October. Most of the rain falls at the beginning and at the end of the season. In July and August, strong, dry winds prevail. From November to February the climate is uniformly cool and pleasant. From the middle of February till the end of April, there is a conspicuous

rise in the temperature, but this is lowered by the first showers of the monsoon.

Cotton is generally grown on light, upland, red soils, which are rather poor, but owing to high cotton prices its cultivation is being extended to the black soils, where wheat is normally more profitable.

Varieties of Cotton grown.—Except for the variety known as *wa-gyi* and scattered plants of Cambodia and Caravonica, *G. neglectum* is the only cotton grown, and of this there are three kinds. *Wa-gale*, a mixture in which *G. n. verum burmanicum* predominates, has a staple of $\frac{1}{2}$ to $\frac{3}{4}$ inch and a ginning percentage of 28 to 33. *Wa-pyu*, *G. n. roseum avense*, and *wa-ni*, *G. n. verum Kokatia*, are met with in the *wa-gale* mixture. *Wa-ni* has khaki-coloured lint and is regarded as an impurity, so that large numbers of coolies have to be employed at the ginneries to pick it out. *Wa-gyi*, *G. obtusifolium* var. *Nanking*, is grown in Thayetmyo and Prome; it has a staple of $\frac{3}{4}$ inch and a ginning percentage of 39 to 40. A cotton which appears to be an Asiatic type, closely related to *G. neglectum*, is grown in the northern Shan States, and has a staple of about 1 inch but a very low ginning percentage.

Experiments with exotic cottons commenced in 1890 and were continued spasmodically for about twenty years, but without success. A similar result attended the experiments with *buri*, Broach, and Egyptian cottons, that were instituted at the Tatkon farm in 1914; but more success was achieved with the native varieties, especially as regards improvement in the ginning percentage. A white-flowered strain of *wa-gale* has been selected that has a ginning percentage of 40 as against 33 for the ordinary variety. Another selection is from *wa-gyi* with a ginning percentage of 45 against a normal percentage of 40. Four strains have been selected from *wa-gale* at the Padu farm in the Sagaing district, with a ginning percentage of 34 to 38, and seed of these has been given out to co-operative societies in the district. At Allanmyo, in the Thayetmyo district, Cambodia cotton has yielded 1200 lb. of seed cotton per acre on 4 acres of abandoned riceland.

The Burma cotton-growing districts appear to offer a wide field for investigation. A botanical survey is necessary, and a classification of all the types grown as regards yield

and ginning percentage, followed by selection work, with the view to the standardisation of the quality of the cotton.

Cotton is sown broadcast, in May, but some success has been achieved by the Agricultural Department in introducing the practice of sowing in lines. The system of cultivation is poor, and the implements used are primitive. *Juar* or sesamum is the usual rotation with cotton, though cotton is sometimes rotated with wheat on the black soils. Occasionally cattle dung and village refuse are thrown on the land and unevenly distributed with a harrow; otherwise no fertilisers are applied. Cotton is not irrigated, for the farmer prefers to grow rice whenever water is available.

Cotton markets do not exist; travelling brokers buy the crop from the growers. Most of the crop is ginned and pressed at Myingyan, but there are factories as well at Allanmyo and Thayetmyo and in the Meiklila district. From these factories the cotton is despatched to Rangoon, from whence it is exported to Japan and Europe.

BIHAR AND ORISSA

In Bihar and Orissa there are 73,000 acres under cotton cultivation, which represents 0.3 per cent both of the cultivated area of the province and of the total area under cotton in India. Saran and Santhal Parganas are the only two districts in Bihar where the area under cotton cultivation exceeds 10,000 acres.

G. intermedium is the variety most commonly grown in Bihar, and principally for domestic purposes, for, owing to its long growing season, it is unpopular. The staple is $\frac{5}{8}$ to $\frac{3}{4}$ inch in length, while the ginning percentage varies from 15 to 30, with an average of 17, which is lower than that of any other cotton in India.

In Orissa no district has as much as 5000 acres under cotton. The cotton comprises a mixture of *neglectum* varieties similar to that already described for the Central Provinces.

The Chota Nagpur division is the original home in India of the acclimatised variety of Upland Georgia cotton known as *buri*, of which the staple is $\frac{7}{8}$ to 1 inch and the ginning percentage is 31. No records are available to show by whom

it was introduced, but it is said to have been grown in this division for about one hundred years. Interest chiefly attaches to *buri*, because of the efforts that have been made to distribute it in the Central Provinces.

Experiments with exotic cottons have not been very successful, except those commenced with *buri*, and with several selected American varieties from Cawnpore and Lyallpur, on the Ranchi farm in Chota Nagpur in 1917, where four of the Cawnpore selections gave better yields than any of the native varieties. There is little indication that the area under native cotton will be greatly increased.

BENGAL

The area under cotton cultivation in Bengal is 48,000 acres, which is 0.2 per cent both of the cropped area and of the total area under cotton in India. In addition, there are about 22,000 acres under cotton in the Native States. The whole of the cotton crop, with the exception of small areas of *neglectum* in Bankura and Midnapore, is grown in the Chittagong Hill tracts. The cotton, which passes under the trade name of Comillas, is *G. cernuum*, of which there is a subvariety with khaki-coloured lint, *G. c. sylhetense*. Comilla cotton is distinguished from other India cottons by the size of its bolls, which in certain cases reach a length of 8 inches, and also by its high ginning percentage, which averages about 43, and sometimes goes up to 50. The staple is very short, $\frac{3}{8}$ to $\frac{1}{2}$ inch, and the lint is so harsh in character that it is commonly used as an adulterant with wool, and its price is consequently said to be regulated by the price of wool rather than by that of cotton. Attempts to grow exotic cotton were abandoned several years ago, for the climatic and other conditions appear to be unsuited for their growth, and, moreover, there does not seem much prospect of any great extension of the area under the indigenous varieties.

ASSAM

The area under cotton in Assam is about 34,000 acres, which constitutes 0.6 per cent of the total cropped area and 0.2 per cent of the total area under cotton in India. The

Garo and the Lushai Hills are the principal cotton-growing districts. As in Bengal, the cotton grown is known as Comillas, *G. cernuum*, and its subvariety *G. c. sylhetense*. Buri and Cambodia cottons have been tested, and gave promising results in 1912, but their cultivation was subsequently abandoned as unprofitable. It is therefore considered desirable that selection work should be conducted with Comilla, with the object of improving and standardising its ginning percentage and its staple as well.

BARODA

The area under cotton in Baroda is about 725,000 acres, or 3·2 per cent of the total area under cotton in India. The percentage of cotton to the total cropped area is estimated at 24, which is not exceeded in any other British province or Native State in India.

Baroda is divided into four districts: Kadi, Baroda, and Navsari in Gujarat, and Amreli in Kathiawar. The soil and climate of these districts are similar to the adjacent Bombay territory; so also are the varieties of cotton grown, and these have already been described. Kadi and Amreli are included in the Dholleras area, and Baroda and Navsari in the Broach area. A mixture of *G. neglectum* varieties, known as *mathio*, is grown in the Amreli district. *Wagad* and *lalio*, the latter under irrigation, are grown in the Kadi district. A mixture of Broach and *goghari*, known as *kanvi*, is grown on the black soils, while on the light soils the perennial variety *rozi*, *G. obtusifolium*, is grown mixed with *kodra*, *Paspalum scrobiculatum*, in the Baroda district. Owing to its higher yield and ginning percentage, the inferior variety *goghari* has of recent years spread as rapidly in the southern districts as in the adjoining British territory.

Experiments with American varieties have not been very successful, and it is considered undesirable to encourage further attempts in this direction. Work has been carried out with the object of improving the native varieties, and it has been recommended that this should be continued, more especially in connection with the Dholleras mixture, the maintenance of the purity of *wagad*, and the restoration of *lalio* to its former degree of purity.

RAJPUTANA

The area under cotton in Rajputana is about 372,000 acres, or 1·7 per cent of the total area under cotton in India. This is exclusive of 45,000 acres in Ajmer-Merwara, which represents 13 per cent of the net cropped area of that province and 0·2 per cent of the total area under cotton in India. Most of the cotton is grown in the eastern portion of the agency, and adjacent to the cotton-growing districts of the United Provinces and Central India. A mixture of the same varieties that is grown in the United Provinces is grown, and, except in Ajmer-Merwara, the crop is hand ginned and is used for hand weaving goods for local consumption. A botanical survey of the cotton-growing districts is needed to determine the variety or varieties to which efforts towards improvement can be best directed.

MYSORE

The area under cotton in Mysore is 115,000 acres, which forms 0·5 per cent of the total area under cotton in India, and 0·2 per cent of the cropped area of the State. Cotton cultivation is almost entirely restricted to the black soil areas of the Chitaldrug and Shimoga district. The varieties of cotton grown are similar to those of the adjacent Bombay districts, *i.e.* *kumpta* and Dharwar American. The mixture of the lint of these two kinds in the ginneries is prevalent to some extent. Selection work has been undertaken with the object of improving the yield and quality of both kinds. It is considered that further experiments with Cambodia under irrigation should be proceeded with.

Crop Forecasts.—Three factors contribute to the preparation of an estimate of crop return under the system in vogue in India. These are: (1) the area, (2) the standard normal out-turn per acre, and (3) the anna estimate or the percentage estimate representing the relation of the year's crop to the normal out-turn per acre. With regard to (1) there exists in the village establishments of most provinces an agency capable of reporting the area under the crop with a great approach to

accuracy. With regard to (2), in each province the Agricultural Department maintains a statement of the average yield per acre of land of average quality. Where necessary, a system of crop-cutting experiments is in force to test the accuracy of these standards of normal yield and to revise them. As to (3) the relation borne by the crop reported on to the normal per acre is represented by the anna estimate or the percentage estimate. Generally the out-turn is estimated in annas or sixteenths ; a certain number of annas is taken to represent the normal out-turn, and the out-turn for the year under report is estimated at so many annas higher or lower than the normal. For the published reports, the American notation is used, 100 representing a normal crop and the estimated out-turn being quoted as a percentage of that crop. The District Officer or the provincial authorities convert the anna estimate into the percentage estimate. The actual forecast published is prepared by the Director of Statistics from the district reports. The Indian cotton crop is persistently underestimated, mainly because of the ingrained pessimism of the Indian farmer and the village officers, who rarely report a normal crop. The trade figures obtained by adding the net exports to the consumption in and outside mills were, on the average of the ten years ended 1917, 9.6 per cent in excess of the official estimate of out-turn. While it is appreciated that in the existing condition of the country's development and its finances the United States system of crop reporting could not be adopted in India, it is an ideal eventually to be worked up to.

In 1905 the Government of India fixed the dates for the publication of cotton forecasts as follows :

	Provincial.	All India.
1st Forecast . . .	10th August	15th August.
2nd " . . .	10th October	15th October.
3rd " . . .	10th December	15th December.
4th " . . .	10th February	15th February.

The date of the final forecast is considered to be too early to enable particulars regarding the whole crop to be included in it, and it has been suggested that a fifth and final forecast should be published in April.

The Department of Statistics publishes fortnightly a

return showing the quantity of cotton pressed in the pressing factories and of unpressed cotton received in the spinning mills during the fortnight, together with progressive totals up to the end of the fortnight. They are, however, far from complete, for the submission of data is entirely voluntary. It is therefore proposed to make the submission of such returns compulsory by legislation. Further, that the submission of estimates of out-turn should everywhere be handed over to the Agricultural Department, and that the Agricultural Department's staff shall be increased accordingly. It is desirable to substitute a quantitative estimate for the anna estimate at present existing, and that yields be reported by primary reporting agencies in terms of seed cotton, the Agricultural Department being responsible for the conversion into terms of ginned cotton.

Cotton Picking.—Careless cotton picking is one of the factors contributory to the unsatisfactory state in which Indian cotton is marketed. Picking methods are especially unsatisfactory in the Kumpta - Dharwar area in Bombay, and in the northern and western areas of Madras. During the operations of the Cotton Frauds Act, 1863, tons of earth and sand were removed from cotton. Sometimes cotton is picked early in the morning when it is wet with dew, no trouble is taken to dry it, and it is marketed in this moist condition. Owing to the dryness of the climate later in the day, the leaves of the plant and the valves of the bolls become so brittle that they get mixed with any cotton picked at this period of the day. Ripe and unripe bolls are picked indiscriminately, owing to the grower's desire to get his crop picked as soon as possible. The seed cotton is frequently piled on the bare ground, and it becomes contaminated with dirt, sand, and small stones. The objection to early cotton picking is readily overcome by spreading it in the sun to dry after it is picked. Losses resulting from bad picking must in the aggregate be considerable through railway freight incurred unnecessarily on foreign substances, and heavy loss in the blow-room. Cotton systematically picked by a large landowner in the Kumpta area lost 5 per cent in the blow-room, as against 12 to 14 per cent from cotton picked in the usual way. Additional processes through which badly picked cotton has to pass, in order to get it into a

condition in which it can be used, weaken the staple. Moreover, it is impossible entirely to extract all the foreign matter, and material manufactured from it is inferior in quality. These defects must obviously react on the price paid to the grower.

The way to improvement lies in convincing the grower that it pays him to pick his cotton clean. Very little has been done in this direction. The Madras Agricultural Department carried out cotton-picking experiments, which demonstrate that in existing circumstances a sufficiently high premium cannot be obtained for clean cotton to make it worth the cultivator's while to produce it. Stained and damaged seed cotton was picked out and marketed separately, but the clean cotton realised very little more than the market rate for ordinary cotton, and considerably less was paid for the remainder. Although the cultivators had incurred extra expense by careful picking, they obtained less, or at any rate no more, than they would have done if the cotton had been marketed in the usual way. These results are of course not conclusive, and probably better results would be obtained if the scheme were extended, say to 100 bales.

The usual procedure is to pay the pickers a proportion of the day's picking, which varies according to the state of the crop throughout the season. Obviously the pickers' sole object is to procure as much seed cotton as possible, which conduces to carelessness. The system has its advantages, for it relieves the grower of the necessity for supervising the pickers, and it expedites the harvesting of the crop. The cotton earned as the day's wages is usually disposed of to the village shopkeeper, who lumps all his purchases together, which provides a fruitful source of seed mixture. Payment in cash or grain would remove this objection, while the supply of bags to the pickers would remove the disability arising from piling the cotton on the bare ground.

Owing to the friability of the leaves of Indian cottons during the drought that obtains at the time of the picking season, it is maintained that it is impossible to pick the cotton in a perfectly clean state. The stronger attachment of the lint to the seed is said to render it more liable to be injured, by tearing or cutting in the ginning process, than is the case with American or Egyptian cotton. The tight

adhesion of the lint to the seed also conduces to the breaking or crushing of the seed, from which oil exudes and stains the fibre. Acclimatised Upland cotton does not seem to suffer to the same extent, and is freer from broken leaf, as the foliage remains more succulent through the harvest; it is possible that the hairiness of the leaves affords protection in this connection.

Marketing the Crop.—As is the case in so many other cotton-growing countries, one of the most serious problems is to secure for the grower an adequate price for his crop. Generally he sells his seed cotton to the local shopkeeper, who is also the money-lender, and to whom he is almost invariably under financial obligations; consequently the cotton is sold at a much lower rate than that current in the market. In certain cases the shopkeeper buys the standing crop. The latter mixes his small purchases together indiscriminately and sells them to up-country dealers, who in turn sell them either to bigger dealers, to large exporting firms, or to ginners who deal in cotton. The last mentioned gin and bale the cotton and send it to mills up-country, or send it to Bombay for consumption there or for export.

The passing of the cotton through so many hands obviously adversely affects the price paid to the grower. It would be to his benefit if some of the middlemen were eliminated and if he sold direct to the large buyers.

The great variety in weights used in cotton transactions, not only in different provinces but in different districts and subdistricts in the same province, has a hampering effect on the cotton trade. Cotton is bought and sold for the most part in Bombay Presidency on the basis of the Bombay *khandi* of 784 lb. of lint. The unit in the south of the Presidency is the *nag* of 336 lb. The *khandi* varies from 160 to 250 lb. in Khandesh, while the *maund* varies from 42 lb. at Bodwad to 144 lb. at Dhulia and Amalner. The Madras *khandi* is only 500 lb. of lint. For both seed cotton and lint there is a special cotton *maund* of 100 lb. at Cawnpore, whereas in other parts of the United Provinces the standard *maund* of 82½ lb. is commonly used for seed cotton, while lint is sold in 400-lb. bales. Only in the Central Provinces and Berar have the weights used in the cotton markets been prescribed by Government, and the *maund* of 28 lb.

is affected both for seed cotton and lint. According to the by-laws of the Nagpur market, the *khandi* is one of 784 lb. of seed cotton, and a *bhoja* means 392 lb. of lint. Many dealers and others are not slow to take advantage of the lack of system in this connection to cheat the grower, and it is a frequent source of loss to him. Much good would accrue to the cotton trade generally if the weights used in cotton transactions were standardised throughout India.

It has been recommended that the standard weights should be sub-multiples of the Bombay *khandi*, which is already in use in so many cotton-growing districts in India, and is therefore well known. The *maund* recommended is that of 28 lb., and should be known as the "cotton maund". A *bhar*, *naga*, or *bhoja* of 392 lb. would then be equal to 14 *maunds*, while 2 *bhars*, *nagas*, or *bhojas* would be equal to one *khandi* of 784 lb. This scale fits in with the ordinary bale of lint which, excepting in the south of Madras where it is 500 lb., is 400 lb. everywhere in India. As the allowance for tare is 8 lb., the net weight of a bale would be exactly half a *khandi*, i.e. 392 lb. Further, that all the weights used in cotton transactions should be in pounds avoirdupois, and that those kept in markets, ginneries, and pressing factories should be 1, 2, 4, 7, 14, 28, 56, and 112 lb., and that weigh-bridges and platform scales should be marked with this scale.

The establishment of open markets is one of the most satisfactory means of securing an adequate price to the grower. These only exist in the Central Provinces and Berar; elsewhere cotton markets are merely a collection of godowns, where merchants store their cotton. In Berar, the cotton markets are established by law, and they are administered under the Berar Cotton and Grain Markets Law of 1897. Under this law, unauthorised markets and bazaars may be prohibited. Markets and bazaars may be notified, and committees may be appointed for the purpose of managing them. Rules may be made for the management of markets and bazaars, the levy, collection, and disposal of fees collected therein, the conditions under which licences may be issued to brokers, weighmen, and measurers; scales, weights, and measures to be used, and their inspection and correction.

In the Central Provinces the system in force differs

from that described above. Municipal Committees have power to frame by-laws under Section 105 of the Central Provinces Municipal Act of 1903, which are subject to confirmation by the Chief Commissioner, for the inspection and regulation of cotton markets, and for the charge of fees for the use of buildings and places therein. These markets have on the whole worked well, and they could be much more generally established with advantage to the cotton industry ; for they promote clean cotton picking, and tend to check cotton damping, mixing, and adulteration, and they bring the cultivators into direct contact with *bona fide* buyers. As a result of the open competition, the growers secure the full competitive price for their crops, and are paid for the full weight of it. The buyers have every facility for inspecting cotton offered for sale and are able to fix prices according to quality.

In regard to cotton, the work of the co-operative societies has been largely confined to the formation of cotton-seed societies and seed unions ; an extension of their activities in the direction of securing for the cotton grower an adequate price for his crop would likewise prove beneficial.

Auction sales of cotton, controlled by Government agency, are desirable in the case of newly introduced varieties of cotton, but after the work has developed sufficiently for about 4000 bales of lint of the new variety to be produced in a season, it should be handed over to other agencies, provided suitable arrangements can be made for proper seed control. As a further means of protecting the grower from fraudulent buyers, the publication of current cotton prices would probably be helpful. It is doubtful whether the publication of Liverpool prices in up-country markets is likely to be of much assistance. But in properly regulated markets that are under the supervision of market committees, the price quoted for the cotton of the district in Bombay, and from it the corresponding price of seed cotton and lint which should obtain in the local market, should be posted, after proper deductions have been allowed for freight, ginning, pressing, and other charges. In the Bombay Presidency the grower has, to a certain extent, made a movement to help himself in improved marketing conditions by organising the co-operative sale of cotton. In 1920 six co-operative

cotton sales societies in the Presidency marketed cotton to the value of Rs.30 lakhs.¹

There is in India no central trade organisation which stands in the same relation to the cotton trade of India as the Liverpool Cotton Association does to the cotton trade of Lancashire. In Bombay there are seven distinct bodies representing different branches of the cotton trade, and none can be considered as representative of the trade as a whole. The Indian Cotton Committee therefore recommended that a central association, to be known as the East India Cotton Association, should take the place of the seven bodies which at present control the cotton trade in Bombay, establish a proper basis of classes of cotton for "Futures" contracts, licence brokers and commissioned houses, establish a clearing-house for settlements at least weekly, take up the question of devising some better methods of classification, and enter into mutual arrangements with the Liverpool Cotton Association for the purpose of improving the marketing of Indian cotton.

Ginneries.—Ginning and pressing factories have combined to form pools in most districts, a system that is in many ways prejudicial to the grower. All members of the pool levy the same charge for ginning and pressing. A portion of the charge considered sufficient to cover the actual cost of ginning and pressing is retained by the factory concerned, and the balance is paid into the pool, and is divided at the end of the season *pro rata* to the number of gins and presses owned by the various members. Rates have consequently been forced up excessively, and against this action the grower has no redress. In most districts ginning and pressing charges, including the pool contribution, work out at Rs.5 to Rs.6 for ginning and a similar sum for pressing a bale of 400 lb. of lint, but in some cases rates as high as Rs.11 or Rs.12 have been levied for each operation.

Most of the ginneries in India are equipped with Platt's single or double action roller gins. A few saw gins are found in the districts where Dharwar American cotton is grown, and there are experimental outfits in the Punjab and Sind. It is maintained that saw gins are not suitable for dealing with any Indian cottons, owing to their tendency

¹ Lakh = £6666 sterling.

to cut the staple. This seems to be a matter that requires very thorough investigation in view of their general use elsewhere for similar classes of cotton. It is, however, admitted that they clean the cotton better than the roller gins, and are more economical of labour, as they are equipped with a suction arrangement for feeding the seed cotton to the gin, and an exhaust delivery of lint in a condenser form. Having regard to the increasing cost of labour and its scarcity in certain areas, such as Sind, the question of adapting an automatic equipment to roller gins for feeding the seed cotton, removing lint, and collecting seed, is under consideration.

In 1919 there were 1940 ginning and pressing factories, employing 140,786 persons; and 30,549 gins, of which 25,207 were in operation during the season 1919-20.

Most of the presses are worked hydraulically, and the density of the bales exceeds that of the bales of all other countries. The net weight of the bale is 392 lb., the weight of the canvas and iron bands being 8 lb. It measures $49 \times 20 \times 17$ inches or 9.64 cubic feet per bale. The average density is thus 42.738 lb. per cubic foot.

Buyers refuse bales that measure more than 12 cubic feet on the ground that they are not "full pressed," but usually the volume of the bale is much smaller than this. As ocean freight is calculated per ton of 40 cubic feet measurement, it is to the exporter's interest to see that his bales are well pressed; generally 100 bales only occupy 26-tons measurement.

Adulteration.---Only to a comparatively small extent is the grower responsible for the reputation that Indian cotton has earned in certain markets for centuries, owing to adulteration, mixing and damping, for the greater part of these practices is effected at the ginneries and presses. The reprehensible practice of mixing cotton waste and cotton fly with good cotton is so prevalent, that strong recommendations have been advanced for "the total prohibition of the transport of such waste by railway, whether in the form of loose 'boras' or full-pressed bales, except from one spinning or weaving mill to another, or from a mill to a port of shipment, such as Bombay". The adulterants in question can only be legitimately used by cotton and woollen mills

in certain lines of manufacture, or for the manufacture of munitions.

Because of the mixture of different qualities of cotton, with few exceptions, long staple cotton rarely reaches the chief markets, especially Bombay, in an unmixed state. This practice presents a more difficult problem than that previously mentioned and, in consequence of the mixture of seed that ensues, it is largely responsible for the deterioration of many of the superior varieties of Indian cotton. Owing to this objectionable practice, many districts which were formerly noted for their superior cotton have acquired a bad reputation with Indian consumers and with exporters as well. Even pure cotton that is received from such districts is regarded with distrust, for it is impossible to detect that cotton contains a small mixture of an inferior variety before it passes through the spinning machinery. Short staple cotton is expressly imported into the areas where long staple cotton is grown, solely for the purpose of being mixed with the latter. This practice is very prevalent in the Broach area of Bombay, and in a measure accounts for the deterioration in the reputation of Broach cotton in recent years. Long staple cotton in Berar and the Kumpta-Dharwar areas suffers in a similar manner. As a remedial measure, it has been recommended that, with certain exceptions, the transport of cotton by railway should be prohibited in the form of loose seed cotton, compressed lint in bags, or in that of half-pressed or full-pressed bales, except to *bona fide* consumers, such as spinning and weaving mills for disposal there or shipment outside India. It would at the same time check another objectionable practice, which consists in railing bales of cotton from one station to another where cotton has a better reputation. Such cotton is re-booked from the latter station to its destination, with the object of misleading the buyer by the marks on the bales and railway receipt as to station of origin of the cotton, and to pay for it accordingly.

The wilful mixture of different varieties in the ginneries would be checked if the trade consistently penalised the mixed cotton. At the ginneries cotton is not only mixed with waste especially imported from the mills for this purpose, but ginning machinery is so adjusted that cut or crushed seed is permitted to pass into the ginned cotton. Seed and seed

cotton are placed in the middle of ginned cotton, watering of cotton takes place, and rain-damaged cotton is mixed with good cotton. Proper care is not taken to prevent seed cotton becoming mixed with ginned cotton. Often the platforms behind the gins, where the seed cotton is stored, are too narrow and some of it falls over into the ginned cotton. As the gins are not kept in proper order, seed and dirt fall from them also into the ginned cotton. The effect of all this must seriously affect the export trade, for many of the mills in England and the Continent, which are accustomed to use clean cotton, do not possess the blow-room machinery suitable for treating cotton in the condition that it is exported from India, and they naturally turn their attention to countries which produce cotton of superior quality. Control of ginning and pressing factories appears to be the only means of bringing about reforms that are so essential. It is considered that these factories should be compelled to take out licences, so that cotton about which complaint is made can be referred back to the ginning or pressing factory from which it issued. To facilitate such reference, special marks and numbers should be assigned to each factory by the licencing authority. Further, conditions attaching to the granting of licences to ginning and pressing factories should be : (1) the erection of factories or the modification of existing factories to conform to an approved standard plan ; (2) the maintenance of gins in proper working order, keeping knives set and rollers adjusted to prevent the passage of cut or crushed seed into the lint ; (3) the keeping of a complete daily record of all cotton ginned and pressed, its origin, and the marks assigned to it ; and (4) access for inspection of factory and records, and the submission of the returns prescribed by Government. Failure to comply with the regulations would result in fines or the withdrawal of the licence and the closing of the factory. Legislative measures enacted with the object of checking fraudulent practices in regard to cotton date back to 1829. The latest enactment of this nature, Act VII. of 1878 (Bombay), was repealed in 1881, for, like its predecessor, it met with no favour from the Bombay mercantile community, and moreover the local opposition was supported by that of the Chambers of Commerce of Liverpool and Manchester. It is, however, significant that, within three years of its repeal,

the Liverpool Chamber of Commerce memorialised the Secretary of State praying for the re-enactment of the special penal provisions against fraud and adulteration, on the ground that these practices in regard to Indian cotton were every year becoming more extensive, more systematic, and more skilful. Since 1881 circumstances have changed considerably, and there appears to be a strong body of opinion both in India and in England which favours a scheme of licencing ginneries and pressing factories.

Central Cotton Committee.—One of the recommendations submitted by the Indian Cotton Committee was the appointment of a Central Cotton Committee with headquarters in Bombay. It expressed the opinion that the only way in which existing difficulties could be overcome was by the establishment of a central body, comprised of officials and non-officials, for the whole of India, on which the trade and the Agricultural Departments could meet on equal terms, and to which the Government of India, Local Governments, the Agricultural Departments, and the trade could all look for authoritative advice on all matters relating to cotton, but that its functions should be mainly advisory. Further, in order that the Central Committee should keep in close touch with the happenings in the various provinces, provincial and local sub-committees would be necessary through and with whom the Central Committee should work. In March 1921 the Government decided to constitute a Central Cotton Committee, and appointed twenty-six members with the Agricultural Adviser to the Government of India as Chairman.

The Indian Cotton Cess Act, which became operative in March 1923, provides for a levy of 4 annas per bale on all cotton, whether it is exported or consumed in Indian mills, for three years; after which the cess is to be automatically reduced to 2 annas per bale. The funds raised in this manner are not paid into Government revenues, but are controlled by the Central Committee, which has been definitely incorporated by the Act and given specific powers of expenditure. The Committee has been strengthened and now numbers thirty-eight members; ten are direct representatives of growers, seven represent Provincial Agricultural Departments, eight for Chambers of Commerce and Millowners' Associations, five for the ginning and manufacturing industry,

four for the principal Indian States where cotton is grown, three nominees of the Government of India, and one for the Empire Cotton Growing Corporation.

As regards the Committee's proposals for checking frauds, such as mixing short and long staple cotton, the Cotton Transport Act, 1923, gives comprehensive powers for the restriction of cotton transport by road and rail, to prevent the importation of inferior cotton into superior cotton tracts for the purpose of mixing.

The East India Cotton Association has been established, and has taken over control of the cotton futures market, the management of the clearing-house, and other purely trade matters. In co-operation with the Corporation, the Committee has sought to afford a general incentive to the delivery of clean cotton, and with this object in view, important changes in the Bombay Market Rules have been introduced. "Tenders" are subject to a mutual allowance clause which permits "on" allowances up to two full grades above the standard. The effects of this rule and the establishment of higher standards have given a marked incentive towards the delivery of cleaner cotton.

Other matters receiving the Committee's attention are legislation for the regulation of gins and presses to check the adulteration of cotton, and the adoption of measures for the better regularisation of cotton markets.

The Empire Cotton Growing Corporation is co-operating with the Committee with the object of developing a market for Indian cottons in Lancashire; commercial spinning tests are being conducted, the raw cottons and the yarns produced therefrom being publicly exhibited.

In November 1924, a Research Institute for the improvement of crops was formally inaugurated at Indore, in Central India, where special attention is given to cotton and the fundamental problems affecting the production of this crop in India. The city of Indore is a rapidly developing cotton manufacturing centre, and is an important commercial and educational centre as well.

The foundation of this Institute has been made possible by the provision of 300 acres of land by the Indore Durbar, the grant of £15,000 for capital expenditure by the Committee, and an annual grant of £9000 for current expenses, besides

the income derived from the land at the disposal of the Institute. The annual grant in question has been provided jointly by the Committee and a number of the Central Indian States.

The Institute is directed by Mr. and Mrs. Howard, whose successful work in connection with the improvement of Indian crops is well known. Mr. Howard will act as Agricultural Adviser to the States, and will thus become intimately associated with the Malwa plateau, which is one of the most important cotton tracts in India. The experiment farm is most favourably situated for crop research work, and includes types of all the black cotton soils met with in India. Features of the Institute will be the maintenance of an up-to-date library on crop production, and the training of post-graduate students selected by the Committee.

Another important feature of the Committee's activities is the provision of a Technological Research Laboratory. In December 1924, the Viceroy opened the Spinning Laboratory and laid the foundation stone of the Research Laboratory at Matunga. The Spinning Laboratory is equipped to undertake properly controlled spinning tests for the Agricultural Departments, and will be able to interpret the results and if necessary arrange for full scale commercial mill trials, the results of which should render it impossible for an unsuitable type of cotton to be issued for general cultivation.

The Research Laboratory, which is adjacent to the Spinning Laboratory, is to be equipped with modern instruments for the chemical, physical, and microscopical investigation of cotton. An extensive series of investigations has been planned into the various types of Indian cottons, and attempts will be made to correlate the properties of the cottons with the results of the spinning tests. For although in the existing state of our knowledge of lint the spinning test is necessary, it is not an ideal test to apply to new varieties, for it is expensive and relatively slow. It is therefore considered that efforts should be made to determine whether it is possible to predict the spinning value of a particular cotton without conducting a spinning test, or at any rate to discover a simple laboratory method that would

provide information sufficient to permit the plant-breeder to select the best type for further work.

The Committee believes this modest Institute to be the only one in the world concentrating on the improvement of the raw material and on the growers' needs. Far-reaching results are anticipated in the way of helping the grower to help himself, and to make cotton cultivation more efficient and more profitable.

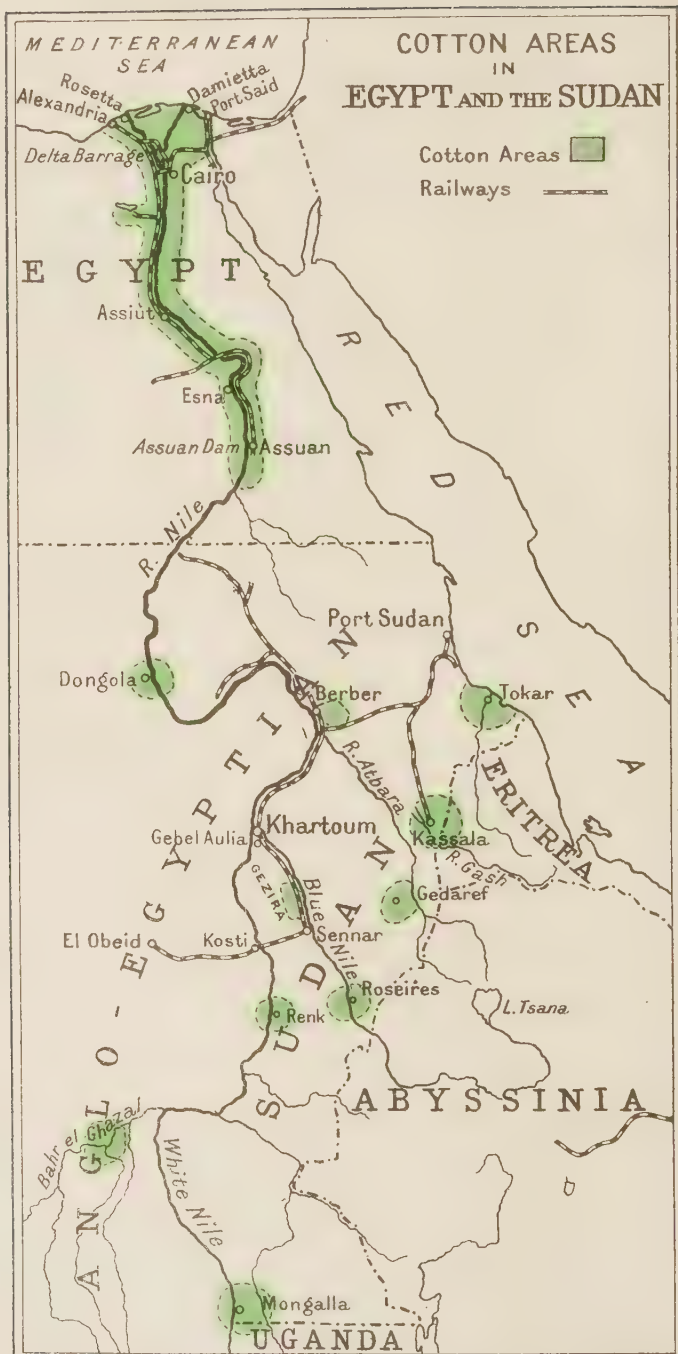
Summary.—During the last twenty-five years considerable development has taken place in the Indian cotton-growing industry, for in that period both the area under cotton and the amount of the crop have been doubled. Unfortunately the average yield of lint per acre is still very low; for the ten seasons 1899–1900 to 1908–1909 the average was 74·2 lb. of lint per acre, and for the ten seasons 1914–1915 to 1923–1924 it was 84·1 lb. of lint per acre. It is also a matter for regret that, although the crop has increased in quantity, too much of the lint has a staple of only $\frac{1}{2}$ inch to $\frac{5}{8}$ inch in length, and at times there exists far too large an exportable margin of such cotton, owing to the fact that the world is unable to absorb a greater quantity of this type of cotton. Moreover, India's production of lint with a staple of from $\frac{7}{8}$ inch to $1\frac{1}{8}$ inch is not greatly in excess of the existing requirements of her own mills.

The increase of the yield per acre and the improvement of the quality of the lint are therefore two factors of cardinal importance to all concerned in the industry, for the grower is not reaping a harvest comparable with that of growers in other countries, while he is labouring at a disadvantage in producing lint below the average requirements of the world's spinners. That there are great possibilities in the latter direction is amply demonstrated by the circumstance that the efforts of the Agricultural Departments in recent years have added 400,000 bales of cotton of approximately one-inch staple to the Indian crop, while the production of cotton over $\frac{7}{8}$ -inch staple has increased from approximately 1,161,000 bales in 1914–15 to 2,107,000 bales in 1924–25. In other words, although the total cotton crop during the period mentioned shows an increase of 44 per cent, the increased production of cotton of over $\frac{7}{8}$ -inch staple amounted to 81·5 per cent.

THE INDIAN COTTON CROP (AREA AND YIELD)

Seasons.	Area. Acres (000's omitted).	Crop. Bales of 400 lb. (000's omitted).	Average Yield of Lint per Acre.
			lb.
1899-1900	11,885	2090	70
1900-1	14,231	2953	83
1901-2	14,506	2745	75
1902-3	16,581	3367	81
1903-4	18,025	3161	70
1904-5	19,918	3791	76
1905-6	20,401	3416	67
1906-7	22,488	4934	88
1907-8	21,630	3122	58
1908-9	19,999	3692	74
1909-10	20,545	4718	92
1910-11	22,596	3889	69
1911-12	21,615	3288	61
1912-13	22,028	4610	84
1913-14	25,023	5066	81
1914-15	24,595	5209	85
1915-16	17,746	3738	84
1916-17	21,745	4489	83
1917-18	25,188	4000	64
1918-19	20,997	3972	76
1919-20	23,352	5796	99
1920-21	21,341	3601	67
1921-22	18,451	4479	97
1923-24	23,636	5162	87
1924-25	26,461	6141	99
* 1925-26	26,305	5569	85

* Estimated.



CHAPTER V

COTTON PRODUCTION IN EGYPT

Geography—Climate—Irrigation essential for agriculture—Population—The cotton crop—Irrigation—Cultivated area—Dams and barrages—Water supply—Assuan Dam—Esna barrage—Assiut barrage—Delta barrage—Water-lifting appliances—Taxes—Water rotations—Drainage—Irrigation and drainage projects—Land reclamation—Land tenure—Phenomenal increase in land value—Soils—Early history of cotton in Egypt—Jumel or Maho cotton—State control of cotton cultivation—Early cultural methods—Varieties of Egyptian cotton—Ashmouni—Mit Afifi—Abassi—Joannovitch—Nubari—Assili—Sakellaridis—Hindi—Zagora—Intrinsic value of Sakel cotton—Cultivation—Irrigating cotton—Fertilisers—Utility of fallow—Crop rotation—Cotton picking—Pests and diseases—Marketing the crop—Ginning and baling—Seed distribution—Mixing cotton—Cotton seed and oil—Crop forecasts—Cotton deterioration—Cotton Research Board—Egyptian cotton statistics.

Geography.—The total area of Egyptian territory comprises some 386,000 square miles, of which less than one-thirtieth, or 12,300 square miles, is cultivable or capable of supporting a settled population. The remainder consists for the most part of desert lands, that are very sparsely populated by nomad Arabs. Situated in the north-east corner of the African continent, it extends from the Mediterranean Sea southwards to the parallel of 22° N. lat., and from the meridian of 25° E. long. to the Suez Canal, Gulf of Suez, and Red Sea.

Climate.—The mean annual temperature of the Delta is 69.1° F. in Alexandria, and 70.3° in Cairo; while it is 80° in Assuan; the extremes are Alexandria 45.1° to 99.3° , and Cairo 36.5° to 109.2° .

From the agricultural standpoint the climate is rainless. The average annual rainfall at Alexandria is 8 inches, at Port Said it is $3\frac{1}{2}$ inches, at Cairo only $\frac{1}{2}$ inch, while south of Cairo, the area which is designated as Upper Egypt, practically no rain falls. Lower Egypt is that portion of the

territory which lies north of Cairo. As regards climate, arid conditions obtain generally, except in the Delta, where the Mediterranean influences increase the rainfall and humidity; the greatest relative humidity occurring from July to September.

Irrigation essential for Agriculture.—Without irrigation agriculture is therefore impracticable, and this is entirely dependent upon the Nile, which traverses the country for a distance of 620 miles from Wadi Halfa, in the south, to Rosetta and Damietta on the Mediterranean coast. As the Nile has not a single tributary in Egypt, the cultivable area is confined to a strip of land about 554 miles in length, which in certain cases is not more than a mile wide on either bank, extending from Assuan to Cairo and to the river delta from Cairo to the Mediterranean. The Delta portion is triangular in shape and was thus named because of its resemblance to the Greek letter Δ (delta). The coast line forms the base 70 miles long, the sides being approximately 120 miles long, with Alexandria, Port Said, and the Delta Barrage respectively at the north-west, north-east, and south corners of the triangle.

Population.—The 1917 Census gave a population of $12\frac{3}{4}$ millions, an increase of about 6 millions since the census of 1882; so that the density of population is more than 1000 per square mile of the inhabited area of the country. The occupation of the greatest part of this population is either directly or indirectly connected with cotton; it exhibits little tendency to emigrate and is increasing at the rate of 200,000 per annum.

The Cotton Crop.—It was largely due to the high prices that obtained for cotton during the American Civil War that caused cotton to come prominently to the front in Egypt, and since that period it has never looked back. The total crop was estimated at 900 kantars¹ in 1821, 228,000 in 1824, 670,000 in 1852, 596,000 in 1861, increasing to 2,140,000 in 1865, and 5,000,000 in 1900. The maximum crop of 7,664,000 kantars was harvested in 1913. Egypt's three basic crops, clover, corn, and cotton, virtually make the

¹ Kantar = 99.05 lb.

farmer self-supporting. Clover is an important factor in supplying the nitrogen deficiency in the soil, and provides green fodder for the animals; wheat or maize supplies the people's food, and cotton their clothing or means of procuring it.

Irrigation.—Irrigation is rendered practicable by means of barrages on the Nile, which supply a system of canals in certain areas, and in others flood basins. The latter system is now confined to Upper Egypt, and is that which was employed from the earliest times. It entailed the diversion of the river, at flood time, through short canals into areas of land surrounded by high banks. The banks prevented the water from escaping, and the soil was enriched by deposits of fine silt that the Nile carries in suspension during flood time, any surplus water being drawn off when the river had fallen sufficiently. It is estimated that the silt was deposited at the rate of as much as one ton per acre. The crops were sown on the muddy sediment in the winter months, and thrived for the most part without further irrigation until they were harvested in the early summer. After harvest the land was fallowed until the following flood. The system was satisfactory for winter crops, but was of little use for summer crops such as cotton. Its success was entirely dependent upon the height of rise of the Nile; if the flood was high copious crops were won, if it was too high much damage was done, while if it was too low it meant famine to many of the people who were settled at a distance from the river. This led to the introduction of perennial irrigation, which was effected by erecting barrages on the Nile, by means of which the water is held up to a more constant level, for the supply at regular intervals to the canal system that traverses the greater part of the cultivable country, and permits the land to be cropped throughout the year. Now, in addition to producing sufficient cereals to supply local requirements and fodder for the cattle, Egypt produces about 6 million kantars of cotton, and this crop occupies about 32 per cent of the total cultivated area.

Cultivated Area.—Out of a total cultivable area of $7\frac{1}{2}$ million feddans,¹ the area actually cultivated is about 5,300,000 feddans; 4 millions of this are perennially irrigated

¹ Feddan = 1.04 acres.

and produce two and three crops per annum, and the remainder receives flood or basin irrigation, or one flooding per season, and produces one crop only during the year. In addition to the above, there are 880,000 feddans of lakes that may be eventually reclaimed for agricultural purposes.

Dams and Barrages.—The water supply is controlled by the Assuan Dam, the Esna, Assiut, Delta, and Zifta Barrages, and in the summer by two earthen dams or suddes in the Rosetta and Damietta branches of the Nile near the sea. Prior to the construction of the Delta Barrage the Nile entered the sea by seven mouths; now its outlet is confined to the Rosetta and Damietta branches. The Delta Barrage was commenced in 1842, but it was not finally completed until 1890. The greatly increased water supply that it provided caused an enormous extension of the cultivated area in the Delta, but the insatiable demand for water continued, especially in the early summer before the arrival of the flood. To satisfy this demand, the Assuan Dam scheme was proposed, and it became an accomplished fact in 1902. As the supply was still inadequate to meet the demand, in 1907 the work of raising the height of the Assuan Dam was taken in hand. The new dam was opened in 1912; it doubled the capacity of the original dam and increased the water-storage accommodation by 308,000 million gallons. Since 1882 the area of cultivated land in Lower Egypt has increased by a million feddans, and about the same area in Upper Egypt has been converted from basin to perennial irrigation.

Water Supply.—When below the normal in summer, the Nile discharges from 6600 to 8800 million gallons per day over a period that varies from 90 to 130 days; this is supplemented by that released from the Assuan Reservoir. At Assuan the Nile discharges, at high flood, some 260,000 million gallons per day. At present, the summer water supply is almost invariably insufficient for the adequate irrigation of the existing cultivated area. For adequate irrigation, this area requires annually 7,260,000 millions of gallons. Although 1913–14 was a year of exceptionally low flood, 9,020,000 million gallons passed Assuan, but the distribution was so unequal that, at one period, water passed uncontrolled to the sea, while at another period there was

actually a shortage. It seems probable that, when the projects for the extension of cotton growing in Egypt and Sudan have been consummated, none of the Nile water will be allowed to reach the sea until it has contributed to some portion of the vast irrigation system.

Assuan Dam.—The Assuan Dam, along with the first Nile cataract, collects and stores water during the winter months, and utilises this to supplement the deficient normal river supply from March or April, until the flood in July produces sufficient for irrigation's requirements. The original Assuan Dam was 175 yards wide and 2188 yards long, but it was raised $6\frac{1}{2}$ yards. There are 140 sluices below, each 15.3 yards square, and 40 upper sluices, each $8\frac{1}{4}$ yards square. The lower sluices allow silted water to pass when the river is in flood. When the flood ceases, about the 1st December, the sluices are closed, and it takes about 100 days to fill the enormous reservoir. The Dam holds up water for a distance of 120 miles.

Esna Barrage.—The first barrage, Esna, which was completed in 1908, is situated 106 miles north of Assuan. It raises the level of low floods and causes the water to enter the canals on the east and west sides, and supplies the basin systems to the north of the barrage.

Assiut Barrage.—The second barrage, Assiut, was completed in 1902, and is situated 249 miles south of Cairo. The cost of this and the Assuan Dam was £E3½ millions. Raising the height of the Assuan Dam cost £E½ million, while this alteration also involved an expenditure of £E1 million to protect the ancient buildings on the island of Philae. The Assiut Barrage controls both the summer and low-flood water, and commands the Ibrahimiya Canal; this canal irrigates the western side of the Nile valley as far as the Delta Barrage. There are many large feeder canals, independent of the Esna and Assiut Barrages, that take direct from the river and feed basin systems east and west of the river. In the areas that cannot obtain free flow or gravitation irrigation from the canals, thousands of pumps and sagias or Persian wheels raise the water to the land surface.

Delta Barrage.—At the point near Cairo, where the Nile bifurcates into the Damietta, east, and Rosetta, west, branches, barrages have been erected at the heads of these

two branches, and constitute the Delta Barrage which controls the levels and water supply of the main canals. The latter strike off north-west, following the west bank of the Rosetta branch, north between the two branches, and north-east in the direction of Port Said. They are divided into suitable lengths by regulators, and from them ramifications of smaller canals convey the water to all parts of the irrigated area. More than three-quarters of the total cotton crop is grown in the Delta. On the Damietta branch the Zifta Barrage, which was completed in 1902, supplements the supplies at certain periods. The temporary earthen dams or suddes erected at Damietta and Rosetta, near the mouths of these two branches, impound drainage and leakage water that enters the branches, when the Delta Barrage is completely closed, and prevent the salt water mixing with the fresh.

Water-lifting Appliances.—Even where free-flow irrigation is generally practicable, some form of water-lifting appliance is required by the farmer. These appliances assume various forms, in accordance as they may be required to lift the water a few feet or up to 25 feet high. The nattala consists of a basket which is swung by two men with cords; they stand in the water and lift the water-filled basket over the low bank in front of them. The badala is employed for a similar purpose; it is a tipping trough, pivoted at its open end, and is worked by one man. Latterly the Archimedean screw has largely replaced the nattala and the badala, and is employed for lifts of 2 or 3 feet. It is comprised of a wooden cylinder, about 10 feet long, with a diameter of a foot, fitted with iron hoops. Within is a screw-shaped partition running up it spirally. The cylinder is mounted to revolve on its long axis by means of a handle; the lower end dips into the water, and, as the cylinder revolves, the water falls down the screw up to and out of the opposite end of the cylinder. For lifts up to 6 feet, the shadouf is the simplest appliance in use. Between two pillars of dried mud, wood, or stone is a long counterpoised sweep, with a bucket attached to its long end, by means of which one person is able to raise the water required. For lifts of from 6 to 25 feet, various forms of primitive water-wheels are employed, such as the sagia, taboot, and novia, which are turned by blindfolded oxen, buffaloes, or camels. In these a large vertical wheel is fitted with an endless chain

of vessels running over its circumference, which are filled with water by the animals driving a horizontal wheel geared to the vertical one.

Taxes.—A special water tax is not imposed, but water charges are included in the land tax; unirrigated land, however, pays no land tax. To protect cotton fields during the period of water conservation, the watering of maize is not permitted from May to June, *i.e.* until the arrival of the Nile flood. Taxes are not levied on pumping stations, but permission for their erection is required from the irrigation authorities.

Water Rotations.—Rotations of varying intensity are imposed on the canals in spring, summer, and flood. In the spring and summer they are necessary in order to economise the water, and the rotation usually consists of six days' irrigation in every eighteen days. In the flood the canals receive a full supply every alternate week, which suffices for irrigation purposes; their closure is a protective measure against water-logging, and checks the farmer's proneness to over-irrigate his land. Moreover, the circumstance that the canals are running at low level every alternate week causes the canals to function as drains to draw off superfluous irrigation water from the land. With the rise of the flood in August, the basin canals of Upper Egypt are opened, and the basins are kept under water until October or November, and then drained off into the falling river.

The water supply problem is governed by two factors, the height and date of the previous flood, which supplies the storage quantity, and the date of the arrival of the succeeding flood, for the quantity stored at Assuan is practically constant. Notwithstanding the gigantic damming operations undertaken to impound the Nile, in a normal year more than one-half of its annual volume flows into the sea without having served agriculture in any useful manner.

Drainage.—The drains of the Delta flow into the sea, and, in many cases, the drainage of the lowest land is pumped into them. In the western Delta, at Mex, large pumps lift the waters of the Meriut Lake to a height of 10 feet into the sea, for the water that enters the lake by means of the main drains exceeds that evaporated during the cold half of the year. The level of the lake is thus maintained at some 8 feet below

sea-level. In the Gharbia area a large drainage scheme was carried out before the war of 1914, with the result that the drainage of 200,000 feddans of land has been considerably improved.

In January practically all the canals are closed and cleared of silt, if this is necessary, while navigable canals are dredged. As a north wind prevails throughout the year, transport by sailing boats in the latter is favourable even against the tide.

The success of any irrigation scheme is mainly dependent upon an adequate system of drainage. In Egypt the constant demand for more water to cope with the requirements of the continued increase of cultivated land appears to have diverted attention from the cardinal importance of providing drainage works commensurate with the growth of irrigation. Its inadequacy was manifested by a high flood in 1908, followed by an abnormally early and high flood in 1909. In the latter year the fields in many districts became water-logged, for there was an ample water supply, and it was scarcely necessary to enforce the rotation periods; water remained on the surface in some cases, while in others ill effects were caused by seepage from the river and canals; consequently the cotton plants wilted and shed their bolls owing to root asphyxiation. Concurrent with this disaster was a severe boll worm attack. As a result of all this the crop was reduced to such an extent that the estimated harvest of $7\frac{1}{2}$ million kantars only realised 5 million kantars. For some time it had been observed that the crop had not increased in proportion to the extension of the area cultivated with cotton, and it was eventually appreciated that the decrease was at least in a measure attributable to excessive irrigation. This contention was confirmed in subsequent years. In 1910 there was an average flood, but it was late; summer rotations were more strictly enforced and the period of over-watering was delayed; unusually fine warm weather in the autumn promoted the evaporation of soil moisture, so that the crop, which was estimated in October at $6\frac{1}{2}$ million kantars, exceeded the estimate by over a million kantars. Similar conditions obtained in 1911, and despite a severe boll-worm attack, and contrary to the general opinion, a crop of $7\frac{1}{2}$ million kantars

was reaped. A comparatively low Nile in 1912 produced a crop which was little short of that in 1910. The year 1913 saw the lowest Nile on record, but a record crop of over 7½ million kantars was harvested.

As regards statements prevalent to the effect that the land in Egypt had deteriorated, Lord Kitchener asserted in 1912 : “ The land is as good as it was, but in places it has become water-logged, and a great many areas have gone out of cultivation or have very much reduced their acreages under cotton, owing to this water-logged state.”

In deep open soil the tap root of the cotton plant will penetrate to a depth of 6 feet in search of moisture ; when this happens, and the water level is raised by the autumn flood, it is conceivable that the result may be disastrous. Another disadvantage attaching to this circumstance is the injury caused to the organic life, useful bacteria, of the soil. Under basin irrigation, and the early stages of perennial irrigation, the land was exposed each summer to prolonged periods of more or less complete drought ; it became drained and dried and consequently soil water-logging did not take place. By the new system of perennial irrigation the drought period was practically abolished, except when the water supply became abnormally low. As the subsoil of the Delta is salty, even a temporary raising of the subsoil water table by over-watering, seepage, or inadequate drainage causes the surface soil to become salted and noxious to plant life.

Irrigation and Drainage Projects.—In considering the question of improving the drainage of the Delta, it was realised that it is divisible into three different parallel zones : (1) The upper or southern zone, which stands fairly high and is therefore not a great sufferer from water-logging ; (2) the middle zone, which lies lower and is the chief sufferer ; and (3) the northern zone, which has been in a most unsatisfactory position as regards drainage for centuries ; though it was at one time highly cultivated, it has become salted from neglected drainage. By creating an artificial outfall at the sea and establishing a new system of drainage throughout the middle and northern zones, it was proposed not only to remedy the damage to the middle zone but to reclaim the whole northern zone, including the salt lakes, and thus restore an area of

about 1 million feddans. It was estimated that the cost of completing the scheme would be more than compensated for by the value of the land reclaimed. It was anticipated that the projected scheme would add 1 million kantars to the cotton crop of the 2,270,000 feddans under cultivation by drainage improvement, while from 880,000 feddans covered with water or too salty for cultivation, at a moderate estimate and allowing for rotations, $2\frac{1}{2}$ million kantars would be added. The cost of the completed scheme, including water storage, irrigation, and drainage, has been given as £36,000,000. It was anticipated that the scheme would take from fifteen to twenty years to complete, but it would begin to produce results almost immediately. A commencement was made before the war, and pumping plant was ordered from England ; it could not be proceeded with after war began, but operations were proceeded with afterwards.

As additional water storage on the Nile is required before any new land could be brought under cultivation, it was proposed to build a new barrage at Gebel Aulia, just south of Khartum, which was calculated to double the water storage of Egypt, besides assisting in the control of unduly high floods and facilitating flood protection in Egypt.

A scheme of projects or control works to increase the irrigation supply of the Nile Valley, to meet the increased demands in Egypt and Sudan, that was prepared by the Egyptian Ministry of Public Works and published in 1920, is as follows :

(1) A reservoir on the White Nile, with a masonry dam at Gebel Aulia, to increase Egypt's summer supply and afford a valuable measure of protection against high floods.

(2) A small reservoir on the Blue Nile, with its dam at Sennar, to irrigate the Gezira Plain.

(3) A barrage at Nag Hamadi to protect flood cultivation in the part of Upper Egypt as yet unconverted to perennial irrigation, and to supply it with summer water when conversion does take place.

(4) A reservoir on the Upper Blue Nile to increase Sudan's supply and aid in flood control.

(5) A reservoir at Lake Albert to complete the storage necessary to meet the ultimate demands of Egypt.

(6) A channel in the sudd region to assure the Lake Albert reservoir water reaching the main Nile.

It should be observed that the Gezira Scheme, the Blue Nile Barrage, the Delta Drainage Scheme, and the White Nile Dam form one comprehensive whole. The Nile Projects Commission, in their report published in 1920, state : " Considered from a strictly engineering point of view, the White Nile Dam, the Gezira Irrigation Scheme, the Blue Nile (Sennar Dam), and the Nag Hamadi Barrage should be carried out at once ", and expressed the opinion that a dam on the Upper Blue Nile was a feasible and indeed essential project.

The work of constructing the Blue Nile Barrage was begun by Government, but it was handed over to contractors ; excellent progress was made and the dam was completed in 1925. In 1925 the Nile flood was disappointing, and there was insufficient water for the irrigation of about a quarter of a million acres of rice in Upper Egypt. Again the necessity of additional storage facilities for summer water was emphasised ; it is therefore interesting to note that the Government has approved the expenditure of over £5,000,000 upon new works at Gebel Aulia, in Sudan, and Nag Hamadi, which are designed to provide the extra water at a time when it is most required.

Land Reclamation.—The triangle-shaped lands of the Delta are separated from the desert on the east and west by canals, while on the north they are bounded by the Mediterranean. Along the shores of the latter there is an almost continuous series of more or less salt lakes. Lake Mariut is situated at the north-west point, and east of it, in the following order, are : Lakes Edku, Borollos, and Menzaleh, with Port Said, at the entrance to the Suez Canal, on the extreme east. Lake Aboukir originally lay between Lakes Mariut and Edku, but this has been drained and is now cultivated by the Aboukir Land Company. Lake Mariut does not connect with the sea, and, as already mentioned, its level is maintained for drainage purposes by pumping. The other three lakes connect with the sea and this controls their level. One of the effects of the Delta Barrage was the increased amount of water that drained into these lakes.

Land reclamation in Egypt usually occupies three years.

The methods employed by the Aboukir Land Company in reclaiming and exploiting Lake Aboukir have been generally adopted. The dimensions of Lake Aboukir are: length, east to west, $7\frac{3}{4}$ miles; width, $5\frac{3}{4}$ miles; area, 30,000 feddans. The bed of the lake is nearly dead level. It was not a permanent lake, but drainage from the adjoining cultivated land on the east and winter rainfall caused the water to accumulate to a depth of a foot in the winter; but this evaporated in summer, leaving a crust of salt. It had been previously cultivated, for traces remained of old water channels and house foundations, so that cultivation was probably interrupted by sea irruption. Prior to washing operations the soil of the lake bed contained more than 8 per cent of salt, whereas fully cultivated land in the neighbourhood only contained 0.01 per cent of salt. The concession of Lake Aboukir was permitted by the Egyptian Government conditionally upon the construction of main canals and drains and the installation of large drainage pumps; this work was accomplished in eighteen months. The drainage pumps comprised two 48-inch centrifugals driven by direct-acting compound engines, which delivered the drainage water into Aboukir Bay. Government subsequently permitted syphons to be made under Mahmoudieh Canal, and by their aid the drainage was caused to flow to Lake Mareotis, the surface of which is 6 feet lower than Aboukir, thus affording a better drainage system than could be obtained by pumping.

After the land had been drained, it was levelled by steam rollers and large wooden scoops and boards drawn by horses. It was then divided into plots with a drainage canal on three sides and an irrigation canal on the fourth side. The main drains and canals divide the area into six divisions or kisms of 5000 feddans (5200 acres) each; where possible they are given a slope of $\frac{1}{10,000}$, but extreme flatness or an adverse rise necessitated a minimum slope of $\frac{1}{20,000}$ in certain circumstances. The main canals, when running full, are calculated to supply about 8000 gallons per feddan per day, and this supply is increased by a high Nile. Although the drains have the same sectional area as the corresponding canals, they have a greater depth; they are useless if they are run full to the ground level, for, although the drainage water comprises only one-third of the amount of the irrigation

water used for crops, to be efficient they should only carry water in from one-third to one-half of their depth. During the first stages of washing the salt out of the land the proportion is naturally much more than one-third.

A kism is divided by secondary canals and drains into hods measuring 1750×1100 yards or 381 feddans (396 acres). These canals are calculated to carry 13,200 gallons per day ; their minimum slope is $\frac{1}{10,000}$, but greater if practicable.

A hod is divided into 8 hoshays measuring 1100×220 yards (50 acres). There is a canal and a drain, with a road between, at the side of a hoshay.

A hoshay is divided into 24 gattas measuring 220×45 yards or approximately 2 acres. Permanent irrigation channels are not necessary for gattas, as channels are made by a wide plough-rut each time the land is ploughed. Their drains are small and only measure 2.6 to 3.25 feet deep, 0.8 foot wide at the base, and 3.25 to 4 feet wide at the top.

The washing of the salty soil is conducted as follows: After the canals and drains are completed, the soil thrown up in making the drains forms a bank all round a gatta. The gatta is flooded about 4 inches deep with water admitted from a hoshay canal. As the water percolates through to the drains, it dissolves out the salt ; the rate of the water's movement is determined by the soil's porosity. Sometimes the soil dries within twenty-four hours, while in other cases it may take a week to dry. Provided water is abundant, washing proceeds from October to April. Constant attention is necessary to see that the gattas are kept filled with water, but not permitted to overflow, that banks are not broken by wave action caused by wind, and that soil slips into drains are promptly removed, all of which check the reclamation scheme.

The land is dried off in April, then ploughed and sown with millet, *Panicum crus-galli*, which makes good fodder for the cattle, either in the green state or as hay. Rice also can be grown, but it is more susceptible to salt. If the millet or rice has grown satisfactorily, clover is sown in October ; if not, washing is resumed for another season. Under the most favourable circumstances, and more particularly on porous soil, land has been let to tenants twelve

months after it was first taken in hand ; but this is exceptional, for two and more often three years are required to bring it into a condition suitable for letting ; the ultimate test being the production of a good clover crop.

Cotton follows clover in March after three cuttings of clover have been taken. A portion of the clover is left for seed, and this yields five cuttings up to June. The clover land is ploughed three times with the native plough, and is then made up into ridges 32 inches apart. Fifteen to twenty seeds are dibbled into each hole, the holes being 20 inches apart ; 35 lb. of seed are used per feddan. To ensure the planting of good quality seed, the company buys seed on a ginner's recommendation, or through the Government Agricultural Agency, and distributes it to tenants at cost price. The young plants are thinned to two in a stand, so that a feddan contains approximately 10,500 "double" plants.

Tenants are given leases for three years. An average holding comprises 8 feddans, including two rooms with an enclosure ; but under the most favourable conditions from 1 to 2 feddans supports a farmer and his family in comfort. The tenant looks to cotton to pay his rent, and, according to contract, he hands over the crop to the company, and is credited with any surplus. Accounts are settled each year in December, after the delivery of the cotton crop.

The crops on the remaining portion of his holding belong to the tenant. He usually keeps two buffalo cows, from which profit accrues by the sale of milk, and the close proximity of Alexandria permits him to dispose readily of eggs and vegetables.

Irrigation rotations are strictly enforced, water being supplied for five days, followed by a stoppage for eleven days. Cotton generally does not suffer if it is watered at every alternate rotation. To avoid excessive waste of water, it has to be lifted by bullock-drawn scoop wheels ; moreover it has been observed that the profuse use of the silty water of the early Nile flood in August is conducive to the production of new vegetative growth to the detriment of the maturing bolls. Usually three hoeings are given at about monthly intervals.

Originally the company spent £276,376 on reclaiming 19,377 feddans, which sold for £572,376, thus showing a profit of £295,648. Until 1905 the policy had been to sell the land as soon as it was marketable, but sales were then stopped, and a rental of £37,000 was built up by 1913. At this period the estate supported 20,000 souls, where, prior to the commencement of reclamation operations, none existed.

Land Tenure.—Originally all land was the property of Government, and a tax or tribute of one-tenth was paid for its use. After the subjection to Islam, Ushuri or privileged tithed land was taken away and divided among the conquerors. Karadshi or higher taxed lands Islam permitted the owners to retain. In 1808 Mohammed Ali declared the titles of private owners void, and Government became owner of all the land. Five years later he instituted a general survey of the land, and gave every peasant of age 3 to 4 feddans secured by title-deeds for life. Owing to lack of funds, Ismail Pasha, by law of 1871, gave every one free possession of his land provided he paid his taxes for six years in advance. Full advantage was taken of this and subsequent facilities for acquiring land.

The predominant features of Egyptian land tenure are: exceptionally close subdivision, extreme value, and paucity of natural or recognisable boundaries, all of which result in an enormous amount of litigation. The need for reform in the manner of recording rights over land in Egypt has been long apparent. A complete record of properties is entirely dependent on an accurate property survey. The last re-assessment of the land tax necessitated a progressive survey and record of ownership being conducted throughout the whole country; it occupied fourteen years, and the early portion was out of date before the work was completed. The whole problem was investigated by a commission appointed in 1917, and it is considered that, if its recommendations are carried into effect, Egypt will have a system of registration of title to land adapted to her needs and traditions, and of a standard attained in few other countries.

The existence of an excessive number of very small holdings is primarily due to the Mohammedan law of equal division of inheritances.

In 1896 there were 767,260 proprietors in possession of 5,001,001 feddans. Since 1896 the average size of the holdings has decreased from 6.5 to 2.96 feddans. In 1910 there were 782,639 proprietors of areas of less than a feddan. In 1920 there were 1,866,761 proprietors in possession of 5,535,352 feddans, while there were 1,207,694 proprietors of areas less than 1 feddan.

Some of the "fellaheen" (labourers) receive daily wages averaging between 1s. and 3s., according to the season and districts in which they work; while others take from the landlord, free, a piece of land, varying in size from 1 to 3 acres, according to its fertility, and cultivate it instead of receiving payment for their services to the landlord.

With the view to protect small landowners from money-lenders, and to discourage the indiscriminate advancement of loans to them, in 1913 the Five Feddan Law was promulgated, under which no owner of less than 5 feddans can be sold up under mortgage.

By the law of March 14, 1899, the land tax of agricultural land was fixed at 28.64 per cent of the rental; taking the rental at 5 per cent of the value of the land, this represents a yearly tax of 1.43 per cent on the land value. This is collected by Government on gross areas without deduction for roads, drains, and canals, and carries with it an obligation on the part of Government to supply water. The average rate of tax per feddan for the five decennial periods 1880-1921 was: £E.1.058, £E.1.036, £E.0.762, £E.0.904, and £E.0.905 respectively.

Phenomenal Increase in Land Value.—After the British occupation in 1882, and the improvements of the irrigation and drainage systems, the value of the land increased at a phenomenal rate. Good land, which could have been bought in 1882 for £15 per acre, is now worth more than ten times this sum. In Lower Egypt, good cotton land, which in 1901 was sold for £80, was worth £150 ten years later. During the same period, in Upper Egypt, land prices increased from £50 to £80. With the increase in value of cotton and other agricultural staples, land values have still further appreciated. Large landowners have found it more remunerative to let the land to tenants than to farm it themselves. The rapid rise of cotton prices that commenced about September 1919 and

continued until the spring of 1920 was reflected in land rent values ; rents were increased by 100 per cent on those of the previous year, while an increase of 200 per cent was not uncommon. The average price for Egyptian cotton in Liverpool was in 1913-14, 9·45d. per lb. ; in 1919-20, 60·34d. per lb. ; in 1920-21, 30·24d. per lb. ; and in 1923-24, 21·55d. per lb. The price of F. G. F. Sakel reached its zenith of 92·50d. per lb. in February 1920, or about ten times that of the pre-war rate. The return to normal prices had the anticipated effect ; tenants were unable to pay the absurdly high rents, and were compelled to hand over their cotton crops to the landlords, and to sell their live-stock. Land which had been purchased at the inflated values, owners were obliged to mortgage to meet their obligations. Only 40 per cent of the crop was shipped as compared with 90 per cent at the same period in the previous year. In November 1920 a cotton commission was appointed to investigate and to recommend measures for the alleviation of the economic stress. By decree of December 7, 1920, with certain exceptions, cotton growing was prohibited in the basin lands of Upper Egypt, and elsewhere restricted cotton cultivation to one-third of each owner's estate ; while some farmers had anticipated it by voluntary action to this end, others ignored it altogether. In February 1922 it was definitely announced that the restriction of the cotton acreage would be continued for at least two years more, and in 1924 it was withdrawn.

Soils.—The cultivated land of the Delta was originally occupied by the sea ; it was first covered with sea sand and then with mud from the lagoons, and lastly by Nile silt. The general composition of this river-borne soil is thus of a uniform character ; it is rich in potash, but less so in phosphoric acid, and poor in nitrogenous matter. High percentages of magnesia and the presence of manganese are general from the Delta to Assuan. The soils may be divided into two groups : (1) sandy soils known as *safra*, and (2) clayey soils known as *black* or *soda*. The latter give cotton yields superior both as regards quality and quantity. Judged by chemical analysis, there is no marked difference between these two types, but physically the difference is great, due to the variable relations between the clays and the sands.

Roche has classified these, according to the percentage of clay present, as follows: (1) very light safra, 20 per cent; (2) safra, 20 to 30 per cent; (3) intermediate, 30 to 40 per cent; (4) strong soda, 40 to 60 per cent; (5) very strong soda, 50 to 60 per cent.

The soils of the Nile Valley differ from those of the Delta, for the arable land of the Nile Valley was reclaimed from the desert by repeated deposits of alluvium and they are thus more sandy. In the case of the Delta, the salt of the sea has caused more rapid precipitation of argillaceous matter, which has resulted in the formation of heavy black clay, and the best soils of the Delta are those where this is mixed with sand. The depth of this alluvial soil is as much as 120 feet.

The weathering operations contributory to the fine silt of the river are due to the agents of denudation in the Abyssinian highlands. The White Nile contributes relatively little material of importance, owing to its filtration through the dense vegetable growth in the sudd region of Sudan.

The subsoil of much of the land is salty, especially in the northern portion of the Delta and low-lying areas, and requires to be well washed with fresh water to render it cultivable. In the absence of irrigation and cultivation the salt tends to rise to the surface.

ANALYSES OF TYPICAL EGYPTIAN SOILS AND AVERAGE (FOR TWO YEARS)
OF AUGUST AND SEPTEMBER SILT (BURNS)

	Tanta.	Katr Dawâr.	Disûq.	Mansûra.	Faiyûm.	Matal.	Nile Silt. Average.
Potash . . .	0.55	0.76	0.52	0.56	0.63	0.76	0.53
Lime . . .	3.38	5.90	3.48	3.28	5.53	4.47	3.07
Phosphoric acid (P ₂ O ₅) . . .	0.20	0.30	0.23	0.23	0.22	0.28	0.25
Organic matter .	7.79	9.10	6.87	7.76	7.38	7.78	8.82
Containing nitro- gen . . .	0.07	0.14	0.09	0.07	0.05	0.095	0.145

Early History of Cotton in Egypt.—The earliest illustration of an Egyptian cotton plant was given by Prosper Alpinus, in 1592, in his *De plantis Aegypti*; this is of a tree cotton that he describes as *G. arboreum*. Bates (*Text. Antiq.*) maintains that cotton was first cultivated in Egypt in the thirteenth or

fourteenth century. The earliest record of cotton cultivation in Egypt is given by Sandars (*Jour. Khed. Ag. Soc.* vol. v.) from an old calendar, dated 1583, which indicates the time for sowing the seed and gathering the bolls, so that it apparently held the position of at least that of a minor crop at that time. For many years its cultivation was little extended as compared with some other crops, such as wheat, millet, and barley. Prosper Alpinus (1592) states, "the herbaceous cotton plant grown in Syria and Cyprus does not grow in Egypt, but a perennial cotton tree is grown in gardens there". This statement probably refers to the Sennar tree cotton, *G. frutescens*, Delille = *G. Nanking* var. *soudanensis*, Watt. The seeds of this plant are large, coarse, with rusty fuzz, which is a constant feature of one group of varieties, except when hybridisation intervenes. Veslingius, who visited Egypt about fifty years later than Alpinus, describes two cotton plants which appear to be identical with (1) the Syrian annual cotton and (2) Hindi, *G. herbaceum* or *G. vitifolium*; with regard to the latter, he specially mentions the whiteness of the lint and the blackish seeds.

Two different kinds of cotton were under cultivation when Napoleon invaded Egypt at the end of the eighteenth century; one was the perennial tree cotton mentioned above, and the other was the Syrian annual cotton. The cultivation of the latter was abandoned, and it is now extinct. At that period cotton cultivation was most common in the Delta and the southern portion of Upper Egypt. The perennial was grown in Upper Egypt and the annual in the Delta. No raw cotton was exported up to 1800.

The principal kinds of cotton that have constituted the bases of Egyptian cotton are: (1) *G. frutescens*, Delille; (2) *G. herbaceum*, L.; (3) *G. vitifolium*, Lamk.; (4) *G. barbadense*, L.; (5) *G. brasiliense*, Macf.; (6) *G. peruvianum*, Cav.; and (7) *G. hirsutum*, L., with its allied or ascentral form *G. punctatum*, Sch. and Thom.

Jumel or Maho Cotton.—About 1820, Jumel, a French-Swiss engineer, was struck with the quality of the lint of a cotton plant that he found growing, for decorative purposes, in the garden of Maho Bey in Cairo. He brought it to the notice of Mohammed Ali, the founder of the Khedivate, with a view to its extensive cultivation for commercial purposes.

Its introduction to cultivation was attended with such success that it rapidly displaced the existing types, for its fine long, strong, brown lint, which was readily separable from its naked seed, rapidly gained favour. The cotton became known as Jumel or Maho cotton, after the persons associated with its introduction. Jumel was a perennial tree cotton; it is placed by Watt under *G. brasiliense*, but other authorities demur on the ground that *G. brasiliense*, the kidney cotton of Sudan, will not fruit readily in Egypt, and no reference of any description can be found showing that kidney cotton was ever found in the Jumel capsules, and they suggest *G. vitifolium*.

State Control of Cotton Cultivation.—Under a system of State control, the plains of Egypt became covered with cotton, even to the neglect of other crops. The area to be grown in each district was determined by departmental officers, and the purchase of the crop was a State monopoly. The lint, being superior to that of India and America, soon found its way to the French and English markets, and established a reputation for Egyptian cotton which exists until to-day. Everything possible was done by Mohammed Ali to establish a good system of cultivation and irrigation by means of the delu or shadouf and by the sakia or Persian water-wheel. The land was well ploughed and the seed was sown on ridges. The fields were watered after sowing, and every twelfth, eighth, and fifteenth day in the spring, summer, and winter respectively. Ginning was performed by means of two wooden rollers superimposed horizontally. A handle was fixed at the opposite end of each roller, and the turning of these caused the rollers to rotate in opposite directions. When the seed cotton was introduced between the rollers, the lint passed through, leaving the cleaned seed behind.

Early Cultural Methods.—Originally cotton was grown as a perennial for ten or more years. After picking the crop, the side branches were pruned back, the fields were fallowed until March and then watered to encourage new growth. Mohammed Ali restricted Jumel cotton to three years, for it was found that although the plants gave an increased yield in the second and third years, the quality of the lint deteriorated as the age of the plants increased. The yield was said to be 1 to $1\frac{1}{4}$ lb. of seed cotton per plant for the first year,

increasing to $1\frac{1}{4}$ to 2 lb. in the two following years. Encouraged by the success of Jumel cotton, Mohammed Ali began to import seeds of different cottons, notably Sea Island and Brazilian, and he endeavoured to maintain the standard of quality by changing the source of the seed supply every five years. The seed of the different varieties was not properly controlled, so that admixture took place and natural crossing in the field soon led to the formation of hybrids. Some of these hybrids were superior to Jumel cotton and were gradually established in its place. It was found that neither Sea Island nor Brazilian cotton could compete with these new selections; but they could not have been kept separate, for it was necessary to sort out the yellow and brown cotton from the pickings off the same field. The ginning percentage was then about 28.5 of lint, and from 336 to 366 lb. of seed cotton were required to yield 100 lb. of lint.

Varieties of Egyptian Cotton.—The first variety to be isolated from the selections referred to above was Ashmouni, on account of its superiority as regards prolificacy, uniformity of staple, and fine creamy-brown coloured lint, with a ginning percentage of 31.8 of lint. It was discovered at Ashmouni about 1860. It spread throughout Lower Egypt and eventually into Upper Egypt; in fact Ashmouni, or old brown Egyptian cotton, was the predominating variety until the appearance of Mit Afifi in 1882. The new variety rapidly replaced Ashmouni in Lower Egypt. Ashmouni still ranks second only in order of importance to Sakellaridis; in 1921 it was grown on 13.3, 57.9, and 81.8 per cent of the cotton area in Lower, Middle, and Upper Egypt respectively. It is certainly the variety that has proved most successful in the hotter and drier climate of Upper Egypt. Ashmouni has thus been under cultivation for more than sixty years, which is a much longer life than that of any other known variety of Egyptian cotton. New varieties brought forward and eventually lost sight of or found little favour are: Quallini, Bamia, Abiad, Hamuli, Hariri, Zafiri, Psikha, Maskas, Sultani, and Voltos. Hindi cotton must not be confused with these, for it is a useless weed. A striking feature of Egyptian cotton cultivation is the manner in which variety after variety came prominently forward, eventually gradually to deteriorate and to disappear.

Ashmouni.—The consistency of Ashmouni cotton as compared with other varieties of Egyptian cotton is well shown in the subjoined schedule :

AREAS (FEDDANS) PLANTED WITH DIFFERENT VARIETIES AT
VARIOUS PERIODS

	1908.	1911.	1922.	1924.
Ashmouni . . .	294,000	330,000	276,000	796,000 (includes Zagora)
Abassi . . .	35,000	33,000	3,000	..
Joannovitch . .	73,000	251,000	..	..
Affi . . .	1,155,000	846,000	8,000	..
Assili . . .	..	..	8,000	..
Nubari . . .	..	115,000	11,000	..
Sakel . . .	..	120,000	1,358,000	873,000
Zagora . . .	..	..	127,000	..
Other varieties .	11,000	16,000	10,000	118,843
Total . . .	1,568,000	1,711,000	1,801,000	1,787,843

In 1924 48·8 per cent of the cotton area was planted with Sakel, 44·5 per cent with Ashmouni and Zagora, and 6·7 per cent with other varieties.

Mit Affi.—Mit Afifi or Afifi was found by a Greek merchant in a field of Ashmouni near a village called Mit Afifi, and the lint was introduced commercially in 1887. Its lint was longer—1½ inch as against 1¼ inch for Ashmouni—stronger, finer, and softer than that of Ashmouni, while it had the high ginning percentage of 35 to 36 of lint. It came into rapid favour. In 1906, 77 per cent of the Egyptian crop was comprised of this kind, but by 1910 it had fallen to 62 per cent. Since the latter date it has declined in favour of other brown cottons, such as Nubari and Assili, but more particularly by the white Sakel. In 1921, 74 per cent of the total cotton area was under Sakel and only 2·5 per cent was under Afifi. Afifi formed the bulk of Egyptian cotton for many years, and the price of “Fully Good Fair Brown” cotton of this variety was the basis price of the Egyptian market in Liverpool; indeed the Lancashire cotton spinner looked upon Afifi as Egyptian cotton, for the other grades were referred to by their distinctive names. The predominance of brown cotton in Egypt has been terminated by the appear-

ance of Sakel, and the basis has been altered to "Fully Good Fair Sakellaridis."

Abassi.—Abassi was selected from either Afifi or Zafiri in 1893, and was named after Khedive Abbas Hilmi. The lint was pure white and very brilliant; although it was not as strong as that of Afifi, it was longer and finer. It met with little favour at first on account of the objection to white cottons since the ascendancy of Afifi. After several years it increased in favour and realised high prices, for it was reported to be particularly suitable for mercerising. Its ginning percentage was 32 to 34 of lint. Abassi never seems to have been cultivated on more than 3·6 per cent of the total cotton area, and in 1921 it was grown on less than 1 per cent.

Joannovitch.—Joannovitch is regarded either as a cross of Afifi and Gallini, or a selection from the latter. It was introduced by M. Joannovitch in 1894, when its lint was described as pure white, longer— $1\frac{1}{2}$ to $1\frac{5}{8}$ inch—finer, and stronger than that of any other kind at that time, with a ginning return equal to that of Ashmouni. It was, however, inferior to both Afifi and Abassi in ginning out-turn, and, although in 1898 it is reported to have realised a price twice as high as Afifi, spinners found more waste than in some of the other kinds. The largest area was grown with it in 1911, when it comprised 14·7 per cent of the total cotton area; in 1921 it was only grown on some 300 feddans.

Nubari.—Nubari originated in a field of Afifi in 1905, and was propagated by H. E. Boghos Pasha Nubar, after whom it was named. Although its lint resembles that of Afifi, it is generally of a superior quality, while the plants have a more vigorous growth. It reached its maximum favour in 1914, when it was planted on 15 per cent of the total cotton area. Since that date it has steadily declined in favour, principally owing to the popularity of Sakel. In 1921 it fell to 0·7 per cent.

Assili.—Assili was selected in a field of Afifi in 1906–7. It differed from Afifi in its longer bolls and the superior lustre of its lint, while it had a ginning percentage of 35 of lint, and some samples were said to have yielded 36·6 per cent of lint. This variety was carefully propagated and the seed was sold at a high rate for several years. The

circumstance that Assili cotton had a high ginning percentage was an immense advantage from the ginner's standpoint, but it had the reverse effect on the growers, for they found that the lower proportion of seed weight required to be made up in lint, and consequently a much greater bulk of Assili cotton was necessary to make up a given weight than was necessary in the case of other cottons. As Affi and Assili were quoted as one grade on the Alexandria market, it seems unfortunate that the obvious method of overcoming the objection was not adopted, viz. the payment of a higher price for the Assili seed cotton. Assili was most extensively cultivated in 1914, when it reached 7·7 per cent of the total cotton area; it steadily declined in favour, and in 1921 it had fallen to 0·5 per cent.

Sakellaridis.—*Sakellaridis* was also selected in a field of Affi, in 1906–7. The lint is white and resembles Sea Island in fineness and silkiness, and the finer qualities of Sakel have proved a serious competitor to Georgia and Florida Sea Island cotton, a variety which has never been a success in Egypt. The seed has a green woolly tuft at each end. The ginning out-turn is slightly higher than Joannovitch. It yields well and can apparently be grown anywhere in Lower Egypt. When first introduced it was condemned by spinners on the ground that it could only meet a very limited demand and could not replace the brown cottons. Contrary to this opinion, it has been favourably taken up both by the grower and the spinner; and, moreover, it has now an established position both on the European and the American markets for specific uses, and to which no rival has yet appeared. In Lower Egypt it threatens to drive all the brown cottons out of the field. In 1913 one-fifth of the Delta crop was comprised of Sakel; now it is grown almost exclusively throughout the Delta. Unlike many former favourites, Sakel has exhibited unusual adaptability, besides being superior in many other respects. One of its greatest recommendations, in view of the prevalence of insect pests, is that it matures earlier than any other cotton grown in the country, and produces a very large proportion of its crop at the first picking. It, however, yields less than some of the varieties that it has replaced. It would appear that the production of Sakel is in excess of the demand for

the manufacture of those types of thread for which it is particularly adapted.

Hindi.—The Hindi weed cotton has exerted an adverse influence on Egyptian cottons during the last twenty-five years, by so readily hybridising with them and depreciating them with its inferior lint characteristics. It is not known whether it was introduced from India (Hind), Persia, or America, or whether it is an Egyptian degenerate. It closely resembles the moqui cotton, *G. punctatum* var. *jamaica*, of the American Indians. Its lint is short, brittle, lustreless, coarse, and irregular. Except that its seed is devoid of fuzz, and has a sharp beak, it might readily be mistaken for American Upland, although some of the plants are hirsute and others completely glabrous. The colour of the flower is pale creamy-yellow and the petals are short and broad; the anthers and pollen are usually paler in colour than those of ordinary Egyptian cotton, while, unlike the latter, the style is short and is not much extended beyond the anthers; also the Hindi bolls are more rounded, and they are divided into three to five carpels, four predominating, whereas Egyptian bolls have ordinarily three carpels. Hybrids of Hindi are much more vigorous growers than Hindi; they sometimes grow 9 or 10 feet high and often produce lint of good quality, but their progeny give rise to a good number of pure Hindi plants whose produce serves to depreciate the quality of Egyptian cotton.

Zagora.—Zagora cotton came prominently forward in 1921, and 145,171 feddans were planted with it, which constituted 7.94 per cent of the total cotton area.

The plants of all the varieties of Egyptian cotton are similar in general appearance, and cannot be readily distinguished one from the other even when growing side by side.

Intrinsic Value of Sakel Cotton.—Of all the varieties of Egyptian cotton under cultivation, Sakel appears to be the only one that has an intrinsic value which is rivalled by no other cotton, for it has certain definite physical qualities that the trade requires in order to develop particular qualities in the yarn; the maintenance of its purity is thus important. In view of its relatively low price it has recently been employed for many purposes which do not demand the

intrinsic qualities that it alone possesses. Its decreasing yield of late indicates the necessity for a series of pure-line cultures to be carried out. On the other hand, it has certain undesirable features from an agricultural point of view, so that the establishment of one or more types with the same intrinsic merits as Sakel, but with an improved vegetative habit, is desirable.

Recent examination of samples of Sakel of the 1913 and 1923 crops suggest that the most frequent staple length had decreased from $1\frac{3}{4}$ inch in 1913 to $1\frac{1}{4}$ inch in 1923. It must not, however, be inferred that the samples investigated were typical of the whole crop of those years ; still it indicates the trend of affairs and the desirability of a more complete investigation.

Cultivation.—That the Egyptian farmer's customs, as regards cotton cultivation, are warranted by existing circumstances has been confirmed by the most elaborate investigations of scientists. He realised long ago that the seed must be sown at the right time, which in any one district is virtually constant from year to year ; and that the plants must be grown close together ; but that this is not feasible if larger agricultural implements are employed than the primitive ones in general use. It is conceivable that close planting, in addition to checking excessive vegetative growth, serves to suppress weeds and conserve soil moisture by protecting the soil from the desiccating influences of the fierce sunlight and the hot winds. His instinct for levelling his fields, in order to render irrigation practicable, is phenomenal. With nothing but his eye to guide him, he will plan out a stretch of uneven land into a series of plots, without a variation of more than an inch in level in any one plot, to allow of the whole being properly irrigated from the highest point in the field. For this work the kassabia is used ; it is shaped like the domestic dustpan and is made of wood, with two handles. It is drawn by oxen, and scoops up the soil of the higher portions of the field and conveys it to the hollows and lower levels. Levelling is of great importance for successful irrigation, and is one of the heaviest items of expenditure in preparing new land.

To form the ridges that separate the plots a batana is used, which is comprised of two converging boards ; these collect the surface soil and leave it behind in the form of a

ridge. The ground is rolled by a log of wood drawn by oxen, the driver weighting the log by standing upon it.

After the clover or wheat crop is brought in during January, ploughing takes place in February, first lengthwise and then followed in a few days crosswise. The wheelless plough resembles those depicted on ancient Egyptian tombs : it consists of a wooden pole protected by a metal point, and is drawn through the soil by a pair of yoked oxen. Generally 4 or 5 inches is considered a sufficient depth to plough. When the plough point does not operate deeply enough, the ploughman stands on the heel of the plough. A piece of wood fixed between the pole and the draught-bar throws the soil outwards on both sides to form ridges. Unlike the ordinary plough, it does not turn over the soil ; and, moreover, in certain cases deep ploughing is inadvisable because of the risk of bringing salty soil to the surface. A ploughing team does about half a feddan per day, and is considered sufficient for the work of 10 feddans. On the large estates steam ploughs and improved agricultural implements of all descriptions are in use.

The ridges are formed about 30 inches apart ; these are crossed at right angles alternately by single and double ridges at intervals of 10 yards or so. The groove formed by the double ridge serves as a distributing channel for the irrigation water, which is let out from it into successive groups of ridges.

The heavy hoe or fass takes the place of horse hoes, harrows, and cultivators ; it has a handle 3 feet long and an adze-shaped head.

Sowing is done by hand with the aid of a piece of stick. The ridges invariably run from east to west. Holes for the seed are made about 15 inches apart, a few inches from the top and on the sunny south side of the ridges, where a higher soil temperature obtains. From ten to twelve seeds are sown in a hole, and on heavy land it is a common practice to include a bean seed, the germination of which assists the young cotton plants to break through the hard soil crust. Sowing usually takes place in March, but sometimes it is done as late as April. Although the prevalence of insect pests later in the season is an argument in favour of earlier planting, the cold windy weather in the spring often renders this procedure impracticable. Seed sown in February takes twelve days to germinate, whereas that sown in April will

germinate in five days. Experiments have shown that the 21st of March is a critical planting date. If re-sowing is necessary, it is customary to use soaked seed in order to accelerate germination.

Irrigating Cotton.—The seed is sown in dry ground, but it is given a watering immediately afterwards. As soon as the plants are established, hoeing is done both to destroy weeds and to break up the surface soil. Before the second watering the plants are thinned out by hand, leaving the two strongest plants to a stand. Too frequent watering in the early stages of growth is not conducive to low branching and deep rooting, which are desirable characters to foster. Hoeing proceeds alternately with watering as long as it is practicable, having regard to the size of the plants. The second and third waterings are given at about monthly intervals, but during June, July, and August watering is done about every fourteen days. At each hoeing a little soil is taken from the opposite ridge, so that finally the cotton plants stand on the centre of a ridge. As each watering requires about 350 tons per acre, and nine or ten waterings are given, the total amount of water supplied per acre is from 3150 to 3500 tons, which is equivalent to a rainfall of 31 to 35 inches.

To afford protection from cold, sand storms, and road dust, gambo hemp, *Hibiscus cannabinus*, Linn., is planted on the outside of the fields at the same time as the cotton seed. By September or October this has formed a hedge and is cut down, and the fibre is extracted for rope making.

Fertilisers.—By the old system of basin irrigation, the land more or less retained its normal fertility by the yearly alternation of the clover and cereal crops and the annual silt deposit. The nitrogen-absorbing clover crop is the great standby in supplying a portion of the nitrogen deficiency, but it is not all-sufficing. Still it is difficult sufficiently to appreciate the importance of this crop; indeed it has been regarded as the salvation of Egyptian agriculture.

All growers appreciate the value of manure for cotton, but comparatively few use commercial fertilisers. Heaps of cattle manure may be seen conserved at every village, though unfortunately, owing to fuel shortage, much of this manure is burned. Other local sources of nitrogen are the tafla or nitrogen-bearing shales of Upper Egypt, and the coufri which

is procured from the koms or mounds comprised of the débris left behind by abandoned townships, but this material is becoming exhausted. Analyses of coufri show great variability in their nitrate and sodium chloride content, and the latter in excess is of course injurious. Cotton appears to receive all the available farmyard manure, while the quickly acting coufri and tafla are applied to the maize.

In view of the high cost of imported fertilisers, the problem of supplying the nitrogen deficiency is difficult of solution. It is important to note, in connection with the question of the maintenance of Egyptian soil fertility, the heavy drain that the cotton crop inflicts on the soil of the country. In addition to exporting some 260,000 tons of cotton, Egyptian mills crush over 100,000 tons of seed and export 95 per cent of the cake crushed, while 428,500 tons of seed are exported as well.

Foaden considers that the best fertilisers for Egyptian cotton are Chili saltpetre and superphosphate. Poor soils require 150 lb. and good soils 100 lb. of saltpetre per feddan, which should be supplied as soon as possible after the young plants are thinned. Superphosphate, containing 16 to 18 per cent of phosphoric acid, should be applied at the rate of 4 cwt. per feddan after the last ploughing or two months after sowing.

The importation of commercial fertilisers now amounts to some 70,000 tons annually, and Government has undertaken to distribute this commodity on credit.

Utility of Fallow.—Fortunately, land which is left fallow rapidly increases its fertility owing to bacterial agency. The partial sterilisation of the soil, brought about by the sun's heat during the fallow, conduces to increase the productive power of the soil, owing to the suppression of what may be termed the "harmful factor" in nitrate formation, and consequently the increase of nitrate production.

In view of the economic importance of partial sterilisation of the soil, as demonstrated by Russell in England, experiments were conducted under the Egyptian Ministry of Agriculture to demonstrate to what extent sharaqi or summer fallow is effective in this connection. The sharaqi period is now curtailed seriously by planting maize in July, or even June, instead of at the end of August as hitherto. Records

collected indicate that, where cotton has been sown on land that has been sharaqi the previous year, the yield of cotton is maintained; and in sharaqi complete suppression of the detrimental factor is secured to a depth of 2 inches, and temporary suppression to 7 inches.

Investigations that have been conducted in Egypt show that the important part of the fallow period is 1st July to 15th August, owing to the partial sterilisation of the soil which takes place at this time. It therefore seems probable that the supply of summer water for the earlier sowing of maize is agriculturally unsound so far as cotton production is concerned.

Crop Rotation.—On good Delta soil the rotation of the small holder is: Cotton followed by partly clover and cereals, partly clover and cereals, and then cotton. On large estates a three- or four-year rotation obtains: (1) Clover or beans, then fallow or maize; (2) wheat, barley, flax or potatoes, then maize; (3) clover between the still standing maize, then cotton; or (1) clover then fallow; (2) cotton; (3) clover, beans or cereals, then sesamum or maize; (4) wheat, then maize. On newly reclaimed salt land, rice or samar is always grown first, as both require abundant and regular irrigation. Careful landowners insist on their tenants practising a three-year rotation. The following are typical rotations under these conditions in Lower Egypt:

GOOD COTTON LAND.		POOR COTTON LAND.	
Winter.	Summer.	Winter.	Summer.
1st year :			
Berseem and wheat	maize	berseem	cotton.
2nd year :			
Fallow . . .	cotton	berseem	maize.
3rd year :			
Berseem and wheat	maize	barley	rice or fallow.

According to Balls, farm balance sheets show that growing cotton every other year has been more profitable than a three-year rotation.

Ploughing in the clover is of immense advantage in opening up heavy soil, and in adding organic matter to light soils to render them more retentive of moisture. Clover is usually sown between the cotton plants before the last cotton

picking ; when the cotton plants are pulled up, the field is rolled to allow the irrigation water to cover the clover evenly. The large estates are generally satisfied with one cutting of clover, but the peasant takes two or three crops, which delays the preparation of the land for cotton, so that only two ploughings are possible. Whereas on the large estates the land is ploughed four and even five times before the cotton is sown. After the last crop of clover is cut the peasant usually turns on his cattle and sheep to feed on the plant material left on the ground.

Cotton Picking.—The cotton flowers begin to open in June or July, and continue to open until the autumn. The bolls take from seven to nine weeks to mature, but those which do not mature before the end of October are practically valueless owing to the prevalence of insect pests. In Upper Egypt, where Ashmouni is grown, picking begins at the latter end of August, but in Lower Egypt it begins in September.

The picker ties his outer robe tightly round the waist, and the picked cotton is stuffed into the neck-opening ; when it is stuffed full he walks to the side of the field, unties the waist girdle, and the gown empties itself on the canvas stretched on the ground to receive it. A great deal of the picking is carried out by boys, girls, and old people ; an overseer supervises from ten to fifteen pickers. A child picks about 30 lb. and a man 100 lb. of seed cotton in a day. Each picker's collection is weighed, and then packed into long bags containing about 400 lb., which are sewn up ready for transport to the store. Usually three pickings are made, and these are kept separate, for the first picking is the best and comprises as much as 50 per cent of the total crop. Dew delays picking in the morning, and sometimes it has to be suspended in the evening at five o'clock because of the failing light.

Pests and Diseases.—The "Plagues of Egypt" are still present, but so far as the crops are concerned they are almost entirely of insect origin, for damage by fungus is apparently small. Unfortunately, on occasions insect pests are so numerous that the whole available labour force of the country is required to combat them. In 1913 the pink boll worm alone is estimated to have destroyed a million kantars of cotton valued at 3 million pounds sterling. The most destructive insect pests are the pink boll worm, *Gelechia*

gossypiella, Saunders; *Earias insulana*, another boll worm; and a cotton worm, *Prodenia litura*, Fabr. Further information regarding these pests is given in Chapter XVI.

Marketing the Crop.—A large quantity of the Egyptian cotton crop is sold before it is picked, and sometimes even before it is sown. A great deal of it is sold in the interior to small dealers, and for these small mixed lots the large merchants pay a lower price than the standard. In some cases brokers buy the crop from the peasants, and after a few transactions hand their purchases over to the bank and receive advances. The agents of the large commercial houses buy in accordance with instructions received from their employers. The ginning factories also buy seed cotton direct from the growers, and sell the resultant lint and seed to exporters in Alexandria, or they may sell direct to Europe. In the case of small growers advances are made at interest, and these are recovered when the seed cotton is delivered. The ginning factory may return the lint to the grower and not concern itself with its sale, and retain the seed in payment for the ginning, adjustments being made in accordance with the value of the seed; or ginning may be effected for an agreed price, both lint and seed being returned to the grower.

The cotton grown in the State Domains is sold by public auction in Alexandria. In 1912, Halakas or local cotton markets were instituted by Lord Kitchener, and now they may be found throughout the Delta. These markets are under the supervision of Government agents, reliable weighing machines are available, and current price quotations are published.

Law No. 16 of 1913 aims at preventing the fraudulent admixture of cotton grown in Upper Egypt with Delta cottons. It prohibits the transport of all unginning cotton between Lower and Upper Egypt in either direction, the precise line of demarcation between Lower and Upper Egypt being defined afresh each year.

More recently steps have been taken, by the official control of cotton transport and markets, to prevent the mixing of superior and inferior qualities of cotton.

“Future” business in cotton has been conducted in Alexandria since 1861; it is thus the oldest “future” market, for the establishment dates of the others are: New York, 1870;

Liverpool, 1873; New Orleans, 1880. On the Exchange in Alexandria, "futures" in cotton are dealt with for the months of November, January, March, May, July, August. "Future" transactions are liquidated twice a month, on days fixed at the beginning of the year. The Alexandria General Produce Association has great influence; it fixes the different grades of the various kinds of cotton, acts as a Court of Arbitration, and publishes weekly official prices and actual cotton transactions that have taken place in Alexandria. The standard types that it fixes to serve as a basis for cotton transactions are kept at its offices, and they are altered, if necessary, each December. The basis for "future" transactions is formed by "Fully Good Fair Sakellaridis." The exact rate for the conversion of kantars into lb. is 99·949,223 lb., but it is customary to give an advantage to the spinner by reckoning the kantar at 98·25 lb. The official Egyptian cotton year dates from the beginning of September to the end of August.

Ginning and Baling.—The whole system of ginning, baling, merchanting, and exporting is practically concentrated in a few large commercial houses, whose agents tour the country and watch the state of the growing crop. They operate their own gins and presses, running them for the six months, August to January, at high pressure day and night. At each ginnyery there is one or more mechanical experts in charge of the gins: the so-called "carpenter" whose duty it is to keep each gin in proper working order. There are over 3000 gins in Egypt distributed among some 140 factories. Platt's Macarthy roller gin is in general use, and has long been recognised as the most satisfactory machine for ginning Egyptian cotton. The type originally introduced in 1853 only ginned 20 lb. of lint per hour, but that now in use has a capacity of as much as 120 lb. of lint per hour.

The practice prevalent in some countries of storing seed cotton for three or four weeks to ripen is rarely adopted in Egypt; although this storage is reported to improve the quality of the lint and also to facilitate ginning.

The gins are not fed by suction tubes, because the large number of gins in each factory makes distribution difficult, so the seed cotton is fed to the gins by hand. Some of the factories have as many as 180 gins in operation. Neither

is the cleaned lint taken away by automatic action; box carts pass up and down at the back of the gins and convey the cotton to the press. This procedure is adopted because as the lint is delivered from the gin it sometimes takes fire from different causes, and when this occurs the conflagration is generally confined to the box cart, whereas if an endless conveyer were employed it might readily be introduced to the presses with serious risks. In most modern factories the seed is removed from the gins by mechanical conveyers.

Except in the State Domains, the practice of artificially damping cotton is prevalent. It is defended on the ground that, in passing through the gins, cotton dries and loses its nice appearance, and the addition of moisture is said to restore its elasticity and silkiness. Under normal conditions cotton contains $8\frac{1}{2}$ per cent of moisture, and it is conceivable that under the arid conditions obtaining in Egypt the moisture of cotton may be lower than the normal, so there is probably a certain amount of excuse for the moisture added by the ginner. The average percentage moisture content of various cottons has been ascertained as follows: Indian, $7\frac{1}{2}$; Texas, $8\frac{1}{4}$; Upland, $9\frac{1}{2}$; Egyptian, 8 to 10; China, $12\frac{1}{2}$. Egyptian exporters maintain that dry cotton is brittle, and that it causes the bursting of the bale bands, which necessitates repressing.

The high prices realised for State Domains cotton is not only due to the comparative purity of the seed used, for a special method of cleaning the seed cotton is employed. The seed cotton is passed over a table comprised of slats of wood $\frac{3}{4}$ inch thick, placed about $\frac{1}{2}$ inch apart, arranged at right angles to the length of the table. The table is about 12 feet long by 3 feet wide. Five or six children are stationed on each side of the table. The seed cotton is put on one end of the table, and the children toss it about and pass it from one to the other in the direction of the length of the table until it reaches the other end of the table. Dirt, broken leaf, etc., fall between the slats, and inferior cotton or foreign material not removed in this way is picked out by hand.

Scarto and affriti correspond to American linters; the former is obtained by repressing imperfectly cleaned seed through a roller gin, and the latter by repressing it through a saw gin. Inferior cotton that has been injured by boll worm,

or that picked from stunted or dirty bolls, is also described as scarto.

Ginning returns are expressed as rotls¹ of lint per 315 rotls of seed cotton; so that a variety which yields 100 rotls of lint from 315 rotls of seed cotton is stated to have a ginning out-turn of 100. The ginning out-turn of various varieties is: Assili 110, Voltos 105 to 107, Affi and Abassi 102 to 103, Ashmouni 100, Sakel and Joannovitch 98·5 to 99.

The lint undergoes two pressing operations. First it is hydraulically pressed at the ginneries for transport to Alexandria; at Alexandria these bales are opened, and the cotton is sorted according to grade, watered and repressed by steam power for export. These presses can turn out as many as 76 bales per hour, but their average output is 55 bales per hour. Ever since Egyptian cotton has been produced on an extensive scale the product has been placed on the market properly baled. The bales are less dense than the Indian cotton bales, but are denser than those produced in the United States. As compared with the American system of baling, the Egyptian system of baling effects a great economy of freight and warehouse space, for three Egyptian bales only occupy about the same space as two American bales. Egyptian cotton bales are covered with good Indian jute canvas, bound with 11 hoops, and are sown up at the ends. They are clearly marked on both sides, and have a tare of only 22 lb., with a density of 36 to 38 lb. per cubic foot. The weight of the Egyptian cotton bale increased from 666 lb. in 1885 to 733 lb. in 1895, and to 760 lb. in 1911. It measures 50 × 20 × 30 inches, or approximately 20 cubic feet.

Seed Distribution.—For many years seed merchants, who were also money-lenders, supplied the smaller cultivators with mixed and inferior seed on credit at a high rate of interest. To overcome the objection to this practice the Agricultural Department commenced in 1911 to distribute seed obtained from the largest and most reliable ginners. The seed produced on the State Domains was regarded as some of the best and purest in the country, and until 1912 its surplus was handed over to the Khedivial Agricultural Society for distribution at a fair price to careful cultivators. In 1912 arrangements

¹ Rotl. = 0·9804 lb.

were effected between the Agricultural Department and the most important and careful ginner, that 50 per cent of the seed obtained from the first pickings of cotton brought to them, by cultivators who grew Domains seed, should be placed at the option of the Agricultural Department for redistribution to farmers on credit. The cultivators who received this seed from the Agricultural Department were in turn required to notify the Department of the name of the merchant or ginner to whom they sold their crop. The Egyptian practice of selecting planting seed from the first pickings can only be defended on the ground that later pickings are more subject to insect attack, for later picked seed does not constitutionally affect the resultant plants. A number of farms on the State Domains have been maintained specially for the purpose of producing and distributing cotton seed from selected plants. The efforts of the Domains have merely resulted in the maintenance of a certain fairly constant supply of seed, by what may be termed "bulk selection," but it is doubtful whether they result in any cumulative effect as regards yield increase.

Mixing Cotton.—The practice of mixing different qualities of cotton has been a frequent source of complaint. In 1912 a decree was passed to prevent the mixture of Afifi and Ashmouni cotton, but this was evaded by mixing Afifi with an inferior grade called Okr. A law more recently promulgated prescribes measures to prevent the mixing of different varieties of unginned cotton and cotton seed under penalty of imprisonment not exceeding one week and a fine of P.T.¹ 100, or one only of these penalties. It applies to the following varieties, as well as to any added by the Ministry of Agriculture: Sakel, Pilion, Afifi, Nubari, Assili, Abassi, Casulli, Voltos, Theodora, Fathi, Ashmouni, Zagora, Joannovitch, and Makssussi. Cotton and cotton seed, the object of the contravention, to be seized and confiscated to the profit of the State so far as 5 per cent of their value is concerned; seed obtained from the balance to be in all cases destined for exportation or for pressing.

Cotton Seed and Oil.—The possibility of cotton seed oil as a commercial commodity first came prominently forward in connection with Egyptian cotton seed in 1841, when the first

¹ 97·5 P.T. (Piastre Tarif) = £1.

experiments were conducted at oil mills in Marseilles ; but severe loss attended the venture. Success was ultimately achieved after a lengthy study of refining and associated problems, and the mills in Marseilles were reopened in 1851. Egyptian cotton seed is richer in oil than American seed, for a ton of Egyptian seed yields 48 gallons of crude oil as against 40 gallons from American seed.

Crop Forecasts.—The conditions in Egypt are peculiarly favourable for the collection of crop statistics, for the whole crop is irrigated by Government, and the Survey and Direct Taxes Departments collect the Land Tax, and are thus intimately acquainted with every cultivated plot of land in the country. The tax collectors furnish a fairly early and reliable return of the area sown, which forms the basis of the estimated crop area that is published in July. In 1910 and subsequent occasions these returns were rechecked by the Survey Department, and were found generally satisfactory. As practically the whole crop is exported from Alexandria, accurate statistics of production are available, except for a comparatively small quantity of cotton that is carried over from year to year in the interior, but this amount does not vary much in normal times. Prior to 1903 field drains and water channels were probably not included in the cotton areas, though this has been done since that date. The previous system would thus possibly increase the yield per feddan by about 8 per cent as compared with the method now in vogue.

Cotton Deterioration.—Lancashire spinners have pointed out that the manufacture of Egyptian cotton is a highly specialised trade, both as regards the machinery employed and the goods produced. In the equipment of factories with machinery, calculations are framed as to the type of cotton to be used in them, and the range is naturally limited, because usually 1 inch and $1\frac{1}{2}$ inch staple cotton cannot be profitably spun by the same machinery. Therefore, if a certain class of yarn is being turned out and, without the spinner's knowledge, the character of the cotton is changed, this is reflected in the resultant yarn, for it takes the dye in a different fashion, the finish of the goods is altered, and this results in serious complaints from customers.

Spinners desire a regular and even-running type of cotton,

which is of uniform length and strength and free from moisture. Their complaints about Egyptian cotton have at times resulted in the evolution of a new type of cotton, whereas all that was needed was possibly a reversion to the old type.

The demand is much greater for good medium length staples than for the extra superfine staples, which cannot be utilised except by a relatively small proportion of the spindles; so that if immense quantities are produced of a kind that is not generally used, the natural concomitant is a serious fall in price. Nevertheless, several years ago a large crop of Sakel cotton could be used, and recently practically three-fourths of the crop consisted of Sakel, and the whole of it was used, so that whether it can be used or not is largely dependent on its market price.

A commission that was appointed in 1910 to investigate the causes of the deterioration of Egyptian cotton, came to the conclusion that it was due to overcropping, substituting a two- for a three-year rotation, closer cotton rows, and also a greater number of plants grown in the rows, insect pests, water-logged soil, due to raising the water level in the canals, infiltration from the canals and excessive irrigation in the summer, and the prevalence of Hindi cotton. To these factors may be added lack of fertilisers, natural and artificial, and admixture of types in the field.

Later, short crops concurring with depreciation of quality led to inflated prices, which was naturally exceedingly vexatious to consumers when the quality was falling, and led to their experimenting with inferior cotton. It was found that long-staple Upland cotton could be successfully substituted for Egyptian cotton, and Egypt lost the monopoly that it had previously held.

The remedy is obviously better drainage, less irrigation, improved seed control to avoid natural crossing and prevent the deterioration of varieties, and the continual renewal of the pure seed supply from the laboratory and seed farms, by which uniformity is assured unless mutation takes place.

The Egyptian Council of Ministers decided on 13th January 1926 to increase the Government purchase of spot cotton to a possible limit of half a million kantars, with the object of maintaining a 75 per cent premium in the price of F. G. F. Sakel over American cotton. If and when the

quality of Egyptian cotton reaches \$36 per kantar Government intervention will cease.

In view of the hybrid nature of the Egyptian cotton crop, it is conceivable that new and more valuable types may originate spontaneously through cross-fertilisation, and a constant and vigilant watch should be kept for such eventualities, but proper precautions will have to be taken to protect them from contamination. It is in this manner that all the best Egyptian varieties have originated, but unfortunately they have not been properly controlled, so that great scope is available in this direction in the future. Monetary rewards would doubtlessly afford increased incentive to investigators. For the best results to accrue from such discoveries, it is of course imperative that the Ministry of Agriculture should acquire control of the progeny. The establishment of "pure" seed farms in each different climatic area, for the purpose of maintaining the purity of each variety chosen for cultivation in that area, would also do much towards improving the quality of Egyptian cotton.

It would appear that there is a possibility of very materially increasing the Egyptian cotton crop and improving its quality by more careful cultural attention and proper regard for seed selection. Although the average yield of cotton in the whole country for 1921 was only 3.37 kantars per feddan, the average yield of the experimental plots administered by the Ministry of Agriculture and the State Domains was 4.55 kantars per feddan. These plots were not specially fertile, but were selected for evenness, and they were all situated in Lower Egypt, where the yields were generally lower than in Upper Egypt. The Ministry's selected strains of Upper Egyptian varieties gave an average yield of 6.83 kantars per feddan. The Ministry's experiments, both in 1920 and in 1921, with Lower Egyptian varieties, show that Sakel, grown from Domains seed, in spite of its medium yield and low ginning out-turn, is by far the most profitable variety to grow, with the possible exception of No. 310, which was originated by Balls. Except as regards earliness, reduced watering experiments showed no advantage in favour of lighter watering.

Sakel yields 7 to 8 per cent lower seed cotton, and a ginning out-turn of 8 per cent less, or a total of 15 per cent

less than the old brown cotton previously grown in the Delta, but it is more profitable owing to its superior quality. The loss in crop due to the introduction of Sakel, and the net increase in damage due to insects since the appearance of the pink boll worm may be very conservatively estimated at 25 per cent. The loss attributable to these two factors is thus sufficient to account for the diminished crops recorded since 1913.

The Egyptian cotton industry showed steady development up to 1897, when the highest average yield of 5·80 kantars per feddan was recorded. That the decreased yields of to-day are not primarily due to insect pests is indicated by the circumstance that the cotton worm, boll worm, seed bug, and aphis were known to attack cotton at that period. Moreover, before the appearance of the pink boll worm, the yield had fallen in 1909 to 3·13 kantars per feddan. As the area under cotton has increased, it is conceivable that, owing to the high profits realised by cotton growers, less suitable land has been planted. The change in the percentage of varieties planted has doubtlessly been a contributory factor; in this connection it is significant that the yield of Ashmouni in Upper Egypt, where it has been almost exclusively grown for many years, has been uniformly 4·10 to 4·20 kantars per feddan for the whole period.

The trade appears to be capable of absorbing all the best staple cotton that Egypt is likely to produce, and at its full relative value. This cotton, more nearly than any other, has been found to satisfy the demand for motor car tyres.

Egyptian cottons are impure, for they comprise a mixture of types, and a considerable admixture of crosses between the types. To this admixture the deterioration of its quality, as well as the definite limit of the life of any particular variety is attributable. It therefore follows that selection should be directed to isolating and maintaining the purity of races which yield the standard classes of cotton that the trade demands.

Cotton Research Board.—In 1919 a Cotton Research Board was instituted whose chief functions are to direct research work on cotton and inform itself of such work by similar institutions, discuss problems in regard to the world's cotton supply and their application to Egypt, investigate and

consider all matters affecting cotton-growing in Egypt. The practical aspects of the problem are left to the Ministry of Agriculture. Whether it is desirable to separate practical from research work in this manner is a debatable question, especially having regard to the economic conditions prevailing in Egypt.

EGYPTIAN COTTON STATISTICS ("ANNUAIRE STATISTIQUE")

Year.	Total Cultivated Area, Feddans 1000's.	Area under Cotton, Feddans 1000's.			Percentage of Cotton to Total Cropped Area.	Cotton Crop, 1000 Kantars.	Average Yield per Feddan, Kantars.	Average Price in £E. per Kantar.	Total Value of Cotton Crop, £E. 1000.
		Lower Egypt.	Upper Egypt.	Total.					
								£E. m.	
1895	6,552	928	70	998	16.04	5,276	5.29	2.240	11,818
1896	6,764	968	83	1,051	16.68	5,879	5.60	2.020	11,876
1897	6,848	1,029	99	1,128	16.37	6,544	5.80	1.576	10,313
1898	7,033	1,029	92	1,121	16.40	5,588	4.98	1.782	9,959
1899	7,161	1,065	88	1,153	17.18	6,510	5.64	2.455	15,981
Average	6,872	1,003	87	1,090	16.53	5,960	5.47	2.010	11,979
1900	7,291	1,143	87	1,230	17.14	5.435	4.42	2.759	14,997
1901	7,429	1,145	105	1,250	17.17	6,370	5.10	2.084	13,275
1902	7,339	1,169	107	1,276	18.16	5,839	4.58	2.729	15,934
1903	7,584	1,171	162	1,333	11.94	6,509	4.88	3.330	21,675
1904	7,563	1,193	244	1,467	20.71	6,313	4.39	2.793	17,633
Average	7,441	1,164	141	1,305	18.42	6,093	4.67	2.738	16,683
1905	7,481	1,256	311	1,567	20.14	5,960	3.80	3.197	19,054
1906	7,662	1,260	246	1,506	20.92	6,949	4.61	3.831	26,623
1907	7,598	1,289	314	1,603	21.59	7,235	4.51	3.641	26,342
1908	7,671	1,299	341	1,640	20.83	6,751	4.12	3.091	20,868
1909	7,712	1,327	270	1,597	21.30	5,001	3.13	4.660	23,303
Average	7,625	1,286	297	1,583	20.96	6,379	4.03	3.642	23,233
1910	7,546	1,326	317	1,643	22.68	7,505	4.57	4.132	31,011
1911	7,681	1,347	364	1,711	22.42	7,386	4.32	3.450	25,483
1912	7,712	1,346	376	1,722	22.35	7,499	4.35	3.655	27,409
1913	7,402	1,340	383	1,723	23.71	7,664	4.44	3.803	29,145
1914	7,892	1,373	382	1,755	15.03	6,451	3.67	2.402	15,494
Average	7,647	1,347	364	1,711	22.37	7,301	4.27	3.521	25,707
1915	7,715	937	249	1,186	21.46	4,775	4.02	3.857	18,416
1916	7,686	1,290	366	1,656	21.82	5,060	3.06	7.562	38,267
1917	7,821	1,294	383	1,677	16.82	6,293	3.75	7.703	48,478
1918	7,692	1,024	292	1,316	20.45	4,821	3.66	7.440	35,866
1919	7,807	1,219	355	1,574	23.41	5,572	3.54	17.562	97,849
Average	7,744	1,153	329	1,482	19.14	5,304	3.58	9.007	47,775
1920-21	7,807	1,379	449	1,828	23.41	6,036	3.30	6.900	41,645
1921-22	8,058	1,012	278	1,290	16.01	4,353	3.37	6.858	29,853
1922-23	8,205	1,378	423	1,801	21.94	6,713	3.73	6.142	41,233
1923-24	8,104	1,290	425	1,715	21.17	6,531	3.81	7.959	51,948
1924-25	..	1,265	523	1,788	..	7,274	4.07	..	..
* 1925-26	..	..	..	1,924	..	8,000	4.15	..	..

* Estimated.

CHAPTER VI

COTTON PRODUCTION IN BRAZIL

Cotton grown since early times—Promising outlook for cotton—Geographical, population, and climate—Famine relief works—Commerce—Taxes—Land tenure—The cotton spinning and weaving industry—The cotton industry—Kinds of cotton grown—Defects in the staple—Phenomenal yields—Pests—Ginning and baling—Statistics—San Paulo: Fertile soil—Cotton on abandoned coffee estates—Cotton areas—Cotton cultivation—Cotton grown on share system. Minas Geraes: Cotton areas—Kinds of cotton grown—Cotton cultivation. Bahia: Cotton areas. Parahyba and Rio Grande do Norte: Tree cotton—Serido cotton—Cotton cultivation—Sertao cotton. Sergipe. Alagoas. Pernambuco. Ceara: Irrigation projects—Acarpe reservoir—Cedro reservoir—Patu dam—Oros dam—Cotton cultivation—Ginning and baling—Market conditions. Maranhao: Cotton cultivation in seventeenth century—Cotton areas—Handling the crop. Piahy. Para: Failure of rubber industry. Summary—Brazilian cotton production, by States, in 1924-25.

Cotton Grown since Early Times.—Shortly after the discovery of Brazil, explorers observed the Indians making various articles of cotton, and some of these early manufactures have been preserved in the National Museum at Rio de Janeiro. The plant known as Ganga, or *algodoa sylvestre*, still grows in a wild state in some of the most inaccessible regions. It is considered that the excellent Moco cotton, *G. vitifolium*, and to which further reference will be made later, originated with this plant.

We have already seen that cotton has been grown in Brazil since 1570. At the end of the seventeenth century it was generally grown almost throughout the whole country, considerable quantities being exported to Europe. From 1781 to 1800 Brazil was the chief source of Lancashire's cotton supply. This development continued until the United States became an effective rival. Nevertheless it is reported

that, at the period of the War of Secession, Brazilian cotton exports were equivalent to 355,000 bales, while in 1872 her exports amounted to 346,231 bales. The Brazilian farmer was then producing his cotton solely with slave labour, and it proved a most profitable enterprise. Later, when the North American cotton fields again assumed their supremacy, the Brazilian cotton industry languished; the north reverting to sugar and the south to coffee. With the abolition of slavery in 1888, the large farmers abandoned cotton, and it was only grown in small plots in sufficient quantity to satisfy local domestic requirements.

Promising Outlook for Cotton.—Of recent years the losses sustained in the rubber and coffee industries, coupled with the high prices ruling for cotton, has directed increased attention to cotton cultivation. Brazil's total cotton production, inclusive of exports, mill, hand spinning and weaving consumption, is now estimated at 750,000 bales of 500 lb. Brazil occupies the fifth position among the world's cotton-producing countries; Great Britain is her best customer and Great Britain and France between them take three-quarters of her exports.

Recent developments in Brazil indicate that it is likely to become one of the really big cotton-producing centres of the world; and it is probable that this country offers at present one of the best prospects for an early and substantial addition to the world's supply of good cotton.

For much of the information that I am able to give in regard to the Brazilian cotton industry, I am indebted to Mr. Arno Pearse's two reports on the investigations of the deputations sent to Brazil by the International Federation of Master Cotton Spinners' and Manufacturers' Associations (Manchester, 1924).

Geographical, Population, and Climate.—The United States of Brazil consists of twenty Federated States, the Territory of Acre, and the Federal District in which is situated the capital of the Republic, Rio de Janeiro. It comprises nearly one-half of South America, about one-fifteenth of the area of the world, and is the fourth largest country in the world. Its total area is 3,275,510 square miles; it extends from the equator to 33° 45' S. lat. and its coast line exceeds 4000 miles.

During recent years the population has enormously increased; fifty years ago there were little more than 10 million people in the country. In 1910 the population was only 23 millions, but according to the last census, in 1920, it has increased to 30,645,296. The density of population is therefore very low, only amounting to 9.3 per square mile. The coastal region is most densely populated.

Prior to the Portuguese occupation, Brazil was inhabited by Indians, and the foundation of the Brazilian race may be said to have been laid by the women of the Indian tribes and the early Portuguese immigrants. The existing negro population are the remnants of the African slaves, who were imported into Brazil soon after its discovery in the early portion of the sixteenth century. Later followed admixture with the Spanish, Dutch, and French during their different occupations of various portions of Brazil. Eighty per cent of the population is illiterate. The Federal Government recognises the value of immigration and assists, by means of subsidies, those who are agriculturists and are accompanied by their families. During the ten years 1911–1920, over 818,000 immigrants of various nationalities landed in the country. In San Paulo alone there are said to be 300,000 Italians; men of this nationality are most appreciated in Brazil for agricultural purposes. The cost of living is high. Labour is poorly paid and is of low efficiency. Agriculturally there is a lack of enterprise, and a low standard of cultivation prevails.

Brazil lies entirely within the tropical and sub-tropical zone. Along the coast a hot, moist climate prevails, but inland, owing to prevailing winds and the altitude, the nights are cool, and the atmosphere is dry and even bracing. The greater part of the country consists of plateaux, rarely less than 300 feet high, but for the most part ranging from 1500 to 3000 feet. The country may be conveniently divided into three climatic zones: (1) The region contiguous to the equator and extending to 10° S. lat., where the mean temperature is 80° F.; (2) that extending from 10° S. lat. to the tropic of Capricorn, where in the lowlands the mean temperature varies between 73° and 79°, and 64° to 70° at the higher elevations; and (3) that extending from the tropic of Capri-

corn to $33^{\circ} 45'$ S. lat., where the mean temperature is 61° to 66° . The country is well watered by a heavy rainfall except in the north-east, where the precipitation is most irregular, and seasons of severe drought occur in periods of from five to seven years.

Famine Relief Works.—In former years these droughts have caused widespread famine and distress both to man and beast. The Government is endeavouring to ameliorate these adverse conditions by constructing large and small permanent water reservoirs made of earth, extensive masonry dams to form a series of lakes, and by improving transport facilities. It is anticipated that the lakes, in addition to supplying water and fish to the people living in their vicinity, will irrigate large tracts of land hitherto unusable owing to irregular water supply. It is considered that these projects will benefit an area equal to one-tenth of the whole of Brazil, and which has a population of 8,000,000, or about one-fourth of the total population of the country. In connection with these works, significance attaches to the following extract from a report dated September 1923, by the Commercial Secretary to H.B.M.'s Embassy, Rio de Janeiro: "It is estimated that on the work so far done over 300,000,000 dollars have been spent (say, £7,000,000), and the economic benefit to be derived therefrom still remains doubtful. The works were conceived on far too vast a scale and the whole conception was far too costly. Moreover, even under these conditions it is thought that no proper control of expenditure has in the past been exercised. The completion and upkeep of the work already done demand large resources, of which the present Government does not dispose, while to develop the irrigation system, without which the construction of dams, railways, and high-roads will be almost useless, still further large sums of money are required. It is difficult to see at what satisfactory conclusion the present Government can arrive. To stop work altogether may have disastrous results, in that the funds already spent will have been wasted, while it is difficult to see whence the money is to come to continue the work started on such a gigantic scale."

Commerce.—The chief commodities of Brazil are shown overleaf, together with the value of the exports of each during the year 1921.

Coffee	£34,693,821
Sugar	3,292,503
Frozen and chilled meat	2,376,167
Tobacco (leaf)	1,858,065
Hides	1,766,582
Cocoa	1,682,209
Cotton	1,556,084
Yerba maté	1,491,839
Oil seeds	1,344,742
Rubber	1,195,446

For many years Brazil had relied too much on the production of the two commodities, rubber and coffee. Brazil's wild rubber industry has been ruined by the Asiatic plantation industry, while her exports of coffee have been seriously restricted by the impoverishment of the Central Powers of Europe, and it has been found necessary to resort to an expensive valorisation scheme. Owing to the damage caused by frost and the impoverishment of the soil, coffee yields have seriously depreciated. Although sugar is largely grown, the yield is not comparable with that of Java and Cuba. Increased attention is therefore being devoted to cotton, for many people look to this staple to balance the losses sustained in the coffee and rubber industries. Already cotton has been planted to a considerable extent on abandoned coffee estates and also between rows of coffee trees cut down by frost.

Taxes.—All agricultural products which pass the boundary of a State pay an export tax at a rate fixed each year by each State. The tax is levied whether the produce is sent from one State to another or to countries abroad; but produce that passes through several States only pays tax to the State of its origin. State taxes are also imposed on every machine in the cotton ginning factories.

Land Tenure.—The southern States are largely populated by the immigrants of the nineteenth century. Elsewhere the working classes are frequently of black or mixed origin, and above them is a ruling class of almost purely Portuguese origin to whom the land belongs. There is no lack of land, and the country is free from the evil that is so commonly met with in older countries, *i.e.* the increasing subdivision of land, which becomes more pronounced as time advances.

In the San Paulo coffee-growing districts, the conditions are essentially those of large ownership, and small owners have obtained no foothold. The two outstanding features in the contemporary history of San Paulo are the constitution of a landed aristocracy and the dominance of the old Paulista race. Labour is chiefly provided from the stream of European immigration, usually Italian, which have nothing to tie them to the land, for few buy real estate.

In Rio Grande do Sul and Parana, land is gradually passing into the hands of the immigrant population.

In the State of Para there is an influx of immigrants from other States, and especially from Ceara, whence they have been driven by the famines caused by droughts. The State grants these immigrants or *colonos* about 60 acres of land. If, after the expiration of two years, a *colono* can furnish satisfactory proof that he has actually produced crops on his land, he is presented with his title-deeds free of charge, subject to his defraying the cost of surveying his land.

Liberal laws with a wide perspective prevail for the reception and disposal of immigrants, more especially those affecting the treatment of immigrants who desire to join one of the numerous agricultural colonies in South Brazil. Those who arrive with three or more children are reimbursed the cost of their passages to Brazil, and their possessions are exempt from import duty. Interpreters, lodging, and medical advice are provided free of charge for several days after arrival. An immigrant may select his own locality. Should he elect to join one of these colonies, free transport and maintenance are provided until he is established on the plot that he selects to cultivate. Further, he is provided with food for six months, *i.e.* until his first crop matures. In return, the head of the family must do fifteen days' work each month upon the public works of the colony. The price of the plot is from 5s. to 10s. per acre, and the payment is spread over a number of years. When the first debt has been liquidated, additional plots can be acquired at a lower rate. In the event of the colonist dying, his rights are conserved by law for his wife and family.

The Cotton Spinning and Weaving Industry.—Cottons constitute Brazil's principal manufacture. The Portuguese

Government originally imported from India hand spinners and weavers for the purpose of teaching their craft; the spinning-wheel and the handloom are in common use in the interior to-day. Probably the Indian spinners also introduced the "churkah" gin, for one almost identical with it is employed in the interior.

The first cotton and spinning mills were established in 1775, in Minas Geraes. Assisted by high import duties on foreign cotton goods, and low rates of exchange, the Brazilian cotton-manufacturing industry has made enormous progress during recent years. Minas Geraes has the largest number of mills, but San Paulo and the Federal District have the largest number of spindles. In 1921 there were in Brazil 243 mills, 1,700,000 spindles, and 60,000 looms, employing 130,000 operatives, with an output of 765,000,000 yards. The low rate of exchange prevents any but the very finest European goods competing with the Brazilian manufactures. It is to be observed, however, that a small tax is payable on every yard of cloth that is produced in the mills of Brazil, and every piece of goods must be marked "Brazilian make". Only Brazilian-grown cotton is used in the mills. The bulk of the yarn produced averages 18's to 20's. Most of the mills use much too superior quality cotton for the low counts that they spin; economy could be effected in this direction, but as the mills make handsome profits the subject is not considered worthy of attention. As regards the wastage of cotton in course of manufacture, the mills of San Paulo, Pernambuco, and Natal show 8, 12, and 18 per cent respectively.

The progress of the Brazilian cotton-manufacturing industry is reflected in the decreased imports of manufactured cotton goods into the country. In 1913 Brazil imported 2,713,600 lb. of cotton piece goods, but in 1918 the imports of this material had fallen to 1,444,400 lb. During the same period the imports of unbleached piece goods fell from 525,500 lb. to 54,700 lb.

The Cotton Industry.—The areas suitable and available for cotton production in Brazil are much larger than the American cotton belt. Land and labour can be procured at much lower rates than in North America, so that cotton can be produced at a much lower cost. It is considered that

cotton can be grown at a profit so long as the price does not fall below 10d. per lb. At present there is no expectation of a labour shortage, but should this occur through a further great extension of the industry in the near future, it is likely that the difficulty would be overcome by the anticipated large immigration from Europe in the next few years. Additional labour should also be made available by the depression in the coffee and rubber industries. The industry is, however, likely to make most rapid development in the near future in the States of San Paulo, Pernambuco, Ceara, Parahyba, Rio Grande do Norte, and Bahia.

Kinds of Cotton Grown.—Upland cotton, with a staple of $\frac{7}{8}$ to $1\frac{1}{8}$ inch, is principally grown in San Paulo, while a mixture, in which Upland predominates, is grown in the States of Minas Geraes, Bahia, Alagoas, Sergipe, and part of Pernambuco. In north Brazil, which overlaps some of the States already mentioned, perennial tree cotton is grown, and the plants remain in the ground for from three to seven years; the staple of this cotton is 1 to $1\frac{1}{2}$ inch. The tree cotton known as Serido or Moco sometimes has a staple up to $1\frac{3}{8}$ inch.

Defects in the Staple.—Brazilian cotton is usually strong and white; in commerce it is either known by the name of the port from which it is shipped or the province where it is grown. Generally it lacks uniformity through the planting of mixed seed; five or six kinds can be frequently found growing together in the same field. The variety mixture is one of the primary limiting factors to the industry's development. It also contains an undue proportion of leaf and other impurities as a result of careless picking. Government is attempting to remedy the first-mentioned defect by the establishment of seed farms and the distribution of only one variety of seed in a district. As regards more careful picking, growers maintain that improvement is unlikely to be effected unless sufficient monetary inducement is afforded by the merchants. In Bahia and northern Brazil a considerable difference in price is paid for clean and dirty cotton, but elsewhere little regard is paid to the matter.

In addition to the drawbacks mentioned above, European buyers complain of not being able to get the same grade of cotton supplied when orders are repeated. Hitherto cotton

has been classified in a general way with reference to the district of its production. It is now proposed that classification should be conducted more in accordance with the standards of foreign markets, more especially those prevailing in Liverpool. Official classifiers are to be established at Pernambuco (Recife), Ceara, and Maranhao ; one is already established at San Paulo.

Phenomenal Yields.—Quite phenomenal yields have been recorded. On one estate near Tatuhy in San Paulo State, an average yield of 500 lb. of lint per acre over an area of 1000 acres is reported. The average yield throughout the country is said to be as high as 190 lb. of lint per acre. The Cotton Service of the Ministry of Agriculture calculated the 1922–23 crop at 528,000 bales of 500 lb. from 1,512,000 acres, which gives an average yield of 175 lb. per acre. The 1924–25 crop was estimated at 704,543 500-lb. bales, and was produced on 1,590,389 acres, so that if this estimate is correct the average yield was nearly 222 lb. of lint per acre.

Planting is carried out at different seasons of the year in the north and in the south of the country. In the north, the long staple cottons are planted in December and January, while the Uplands are planted from February to April. In the south, planting is done from September to November. Picking takes place in the north from August to December, and in the south from March to May.

Pests.—In 1919 the pink boll-worm, known locally as *lagarta rosada*, destroyed a great deal of the crop, more especially in San Paulo. As preventive measures, Government insists on the establishment of fumigating chambers at the ginneries, and the fixing of wire netting to apertures in cotton stores. Latterly elaborate provision has been made for machinery to treat the seed by methods similar to those in use in Egypt. Cultivators claim that good results have been achieved with infected seed by spreading it out in the sun at mid-day for three hours. Some of the growers mix the seed with sand or charcoal before spreading it in the sun for the purpose of retaining the heat, and 90 per cent of the insects are said to have been killed in this way. Other growers report satisfactory results in this connection by soaking the seed in a liquid made from boiled cassava root (*Manihot utilisima*, Pohl.). The effectiveness of this remedy

is due to the prussic acid which is formed when this root is crushed in water. The growers have been advised that seed infested with pink boll-worm should be immersed for two minutes in hot water at a temperature not lower than 131° F. and not higher than 140° F. It should be observed that injury to the seed is likely to be caused at a temperature higher than 140° F., whereas a temperature lower than 131° F. has no practical use for the purpose in view.

The leaf-eating cotton worm, *Alabama argillacea*, and the ringworm, *Gasterocercoces gossypii*, which rings the plants at the collar, are also very destructive. Other destructive insect pests are :

			Part of Plant attacked.
Hemiptera	<i>Pyrn hocoridae</i>	<i>Dysdercus ruficollis</i> . . .	boll.
	<i>Lygaeidae</i>	<i>Plociomerus</i> sp. . . .	"
	"	<i>Oncopeltus</i> sp. . . .	"
	<i>Tingitidae</i>	<i>Gorgophia</i> sp. . . .	"
	<i>Aphidae</i>	<i>Aphis gossypii</i> . . .	leaf.
	<i>Coccidae</i>	<i>Saissetia depressa</i> . . .	lint.
	"	<i>Hemichionaspis minor</i> . . .	"
Coleoptera	<i>Lygacidae</i>	<i>Nysius ericae</i> . . .	"
	<i>Chrysomelidae</i>	<i>Colaspis</i> sp. . . .	leaf.
	<i>Mylabridae</i>	<i>Spermophagus Hoffmanseggii</i> .	seed.
Lepidoptera	<i>Arctiidae</i>	<i>Utetheisa ornatrix</i> . . .	leaf.
	"	" <i>bella</i> . . .	"
	<i>Pyrilidae</i>	<i>Ephestia cautella</i> . . .	seed.

Ginning and Baling.—Saw gins are employed for ginning both long and short staple cottons, the small American "Eagle" type being in most general use. Defective ginning often results through lack of attention to the gins, and especially in regard to saw sharpening, and to the matter of adapting the speed of the gins to the class of cotton under treatment. Obviously these defects adversely affect the value of the cotton. Dirty cotton is sometimes passed over a sieve before it is ginned; this process not only eliminates dirt but it loosens the cotton and facilitates ginning. More up-to-date ginneries, also of American manufacture, have been established in some of the chief centres of production. In certain cases, Government has afforded aid in this connection in the shape of loans at a low rate of interest, and an abatement for a number of years on the rate of export taxes

for cotton handled by these factories. Roller gins could be advantageously substituted for saw gins in the handling of the long staple cottons, if the latter were grown unmixed with short staple cotton.

In the interior, hand-screw presses are in general use, which turn out a loosely packed bale of about 140 lb. in weight; the weight of the bales is often restricted in this manner because they have to be transported long distances by mules, one bale being slung on each side of a mule. These bales are frequently insufficiently covered with canvas; as a result much cotton is lost *en route* and the cotton suffers from undue exposure to the weather.

At the exporting houses, the country packed bales are opened and the cotton is cleaned and then rebaled by hydraulic presses. The common procedure in Northern Brazil is as follows: Each bale is sampled in the presence of the seller, and is classified as 1st (primeiro), 2nd (mediano), and 3rd (refugo). The price of mediano is about 50 per cent less than primeiro, but exporters do not buy refugo. The lots are kept separate, and a sorting process takes place. Layers from the open bale are spread on a slanting table composed of small wooden rollers, which allow dirt to fall through. Four men stand on each side of the table and extract dead and dirty cotton, and pass on the good cotton to the next man, who loosens the cotton and withdraws undesirable cotton, and soon, each man pushing the unrejected cotton to his neighbour. A foreman checks the staple of the cotton in each bale as it is opened, and generally supervises the work proceeding on the table. At the end of the table the cotton is passed through a simple apparatus, which is designed for the further opening and mixing of the cotton. It consists of a slowly rotating wooden beater with six arms each $1\frac{1}{2}$ inch wide. These toss the cotton, riddle it and throw it upon an open platform, where men armed with wooden forks continue the loosening and mixing operations, and eventually feed it into one of the weighing boxes that are situated on either side of the platform. The weighing box is in close contact with the press box, and when a weight of 400 lb. is registered, a bell rings, and the cotton is deposited in the press box.

Statistics.—Statistics of the Brazilian cotton industry are given below:

COTTON PRODUCTION IN BALES OF 500 LB. (U.S. COMMERCE REPORTS)

1919	.	.	.	.	.	560,000
1920	.	.	.	.	.	450,000
1921	.	.	.	.	.	540,000
1922	.	.	.	.	.	535,000
1923	.	.	.	.	.	575,000
1924-25	.	.	.	.	.	699,000

EXPORTS OF RAW COTTON BY STATES
(Bales of 500 lb.)

States.	Ports.	1917.	1918.	1919.	1920.
San Paulo . .	Santos	18	62	26,414	49,548
Pernambuco . .	Recife *	15,572	8,242	7,450	17,274
Ceara	Fortaleza	4,836	1,016	5,460	13,116
Federal District .	Rio de Janeiro	62	..	6,504	8,576
Parahyba . . .	Cabedello	1,064	..	132	7,928
Rio Grande do Norte . . .	Natal	2,468	..	740	3,572
Maranhao . . .	Ilha do Cajueiro †	444	220	1,316	3,300
Maranhao . . .	San Luiz	1,602	1,364	3,920	2,398
Para	Belem (Para)	74	418	1,294	1,584
Alagoas	Maceio	..	48	74	1,130
	Other ports	..	..	176	238

* Recife is the shipping port for a great deal of the cotton grown in Parahyba and Rio Grande do Norte.

† Piahy exports via Ilha do Cajueiro.

TOTAL EXPORTS OF RAW COTTON

Year.	Bales of 500 lb.	Year.	Bales of 500 lb.
1913	160,032	1918	11,414
1914	129,396	1919	33,474
1915	23,004	1920	108,662
1916	4,712	1921	86,270
1917	26,140	1922	149,366

SAN PAULO.—San Paulo is the richest and best organised State in the Union. The value of the imports and exports for the whole of Brazil during the year 1919 amounted to £78,177,000 and £130,085,000 respectively, while those of San Paulo amounted respectively in the same year to £25,400,986 and £72,497,333. In other words, the total foreign trade of San Paulo was almost one-half of the total for Brazil. It has 3726 miles of good railways and a large number of hydro-electric works. It has an area of 112,300 square miles and a population of five millions. Its foremost

manufacturing industry is cotton spinning and weaving, and there are 380,000 spindles and 12,750 looms in operation.

Fertile Soil.—With the exception of a narrow strip of land along the coast near Santos, the whole State is composed of a plateau of undulating character, varying in height from 1500 to 3000 feet, where for the most part a rich red volcanic soil is found, and is reported to be one of the most fertile soils in the world.

Cotton on Abandoned Coffee Estates.—San Paulo supplies three-fourths of the world's requirements of coffee, and this commodity is primarily responsible for the prosperous condition of the State. Coffee yields are, however, steadily diminishing through soil impoverishment and the inadequate application of fertilisers. Many coffee estates have also suffered severely from frost. As a consequence old estates are being abandoned, and new ones are being steadily planted on the virgin soil in the north of the State, where it is anticipated that there will be less danger from frost. Cotton is already planted to a considerable extent as a catch crop on many depreciated estates, where it is highly probable that cotton will, in course of time, take the place of coffee, and that advantage will accrue from the change of crop.

Cotton Areas.—Upland is the variety most largely grown. The cotton-growing districts may be divided into three distinct zones, which are situated in Sorocabana, and in the north-west and centre of the State. In all of these the rainfall is satisfactory for cotton-growing, and there is a well-defined dry season for the harvest. It will therefore not be surprising if the Paulistas develop cotton-growing as they developed coffee many years ago.

Cotton Cultivation.—Sorocabana is situated west of the city of San Paulo; in 1920 this district produced 13,200 bales of cotton. Cotton is principally grown by small cultivators by the most primitive methods. Ploughs are not used and plant selection has not been practised. In preparing new land for the crop the brushwood and grass is burnt down, but half-burnt tree trunks, stumps and roots are left scattered about the ground. The hard wood remains for many years, but the soft wood soon rots away. On newly cleared land it is found best to grow maize for one or more seasons, as the rich soil encourages cotton to make too

much vegetative growth at the expense of fruit production. This practice is common in other countries where similar conditions prevail. In November holes for seed planting are chopped with the hoe, as far as possible—having regard for the obstructions mentioned above—in lines four feet apart with a space of three feet between the holes in the lines. Several seeds are planted in each hole, and generally three or four seedlings are allowed to remain at each stand. From one to three hoeings are given during the growing season according to weed growth. The same land is cropped with cotton for two or more consecutive years, and as land is abundant it is then left to fallow for several years. Crop rotation is not practised, but maize, beans, etc., are often grown intermingled with the cotton.

Cotton picking is carelessly done ; it begins early in May, and pickers gather 100 to 110 lb. of seed cotton per day. The lint has a staple of 1 inch, but is irregular. The average yield is said to be as high as 450 lb. of lint per acre. On one estate of 1000 acres, which is rented to tenants, an average yield of 500 lb. of lint per acre is recorded. Where such estates are rented to tenants, each family looks after from 12 to 24 acres. The cotton is sold to the proprietor, who receives 20 per cent of the proceeds for the first year after planting begins, 15 and 12½ per cent respectively in the second and third years, and 10 per cent thereafter ; and in addition 40 per cent of the maize, rice, and beans produced.

Cotton grown on Share System.—In the central zone, coffee is the staple crop, and cotton is chiefly grown on coffee estates that have been injured by frost or abandoned through soil impoverishment. The system in force on one estate may be mentioned as typical of that prevailing in this region.

On this estate some sixty families are allotted about 7½ acres each, and they work on a share system. The tenants retain two-thirds of the crop and hand over one-third to the landlord. The tenants are debited with two-thirds of the cost of manure, and money is advanced to them for implements and other expenses. The average yield on this estate is said to be 360 lb. of lint per acre. The Government Instituto Agronomico, where cotton-growing investigations are in progress, is situated at Campinas in this zone.

At Biriguy, in the north-west zone, some 1700 families

have been settled since 1919 on the lands of the San Paulo Colonisation Company. Here a considerable amount of cotton is grown, along with coffee, maize, and beans. The average yield of cotton over the whole estate is estimated at 500 lb. of lint per acre. Two ginneries have been established on the estate for handling the crop. Land is sold to settlers in lots varying in size from 28 to 560 acres. Generally 30 per cent of the purchase price is paid at the outset, and the balance is met from profits; which in many cases has been found possible within three years from the date that operations commenced.

MINAS GERAES.—This is the fifth largest State in the Union; it is more than twice as large as San Paulo, and has a population of $5\frac{1}{2}$ millions. As is indicated by its name, this State is more noted for its mineral than its agricultural products. It is situated in the interior, and is bounded on the north by Bahia, on the east by Espirito Santo, and on the south by Rio de Janeiro and San Paulo. A plateau extends from the south through the State, and ranges in height from 1300 to 3600 feet. The rainy season extends from October to March, the rest of the year being dry. At present the lack of transport facilities hinders the export trade.

Cotton Areas.—Cotton is not generally cultivated on a large scale, but it is grown in nearly every village for local consumption. The principal cotton-growing districts are: Para, Pitanguy, Formiga, Curnello, Catoni, and Montes Claros in the centre of the State; Arassuahy and Pecanha in the east; Araguary and San Pedros de Uberabinha in the west; and Lencoes do Rio Verde and the banks of the San Francisco River in the north. It is most extensively grown in the last-mentioned area, mainly on account of the ready transport provided by the river; elsewhere the lack of transport is a serious deterrent to the more extensive planting of what is already a generally-grown crop.

The estimated cotton consumption of the local mills is 30,000 bales; as more than one-half of this is imported, it seems anomalous that cotton should be exported, more especially as there is an export tax of 4 per cent *ad valorem*.

Kinds of Cotton grown.—Four different kinds of cotton are grown, and these may be usually found growing together in

the same field. Big Boll or Big Boffe is a type of Upland origin, which produces strong, rather coarse lint with a staple of $\frac{3}{4}$ to $1\frac{3}{8}$ inch, and seeds coated with a greenish fuzz. It has a ginning percentage of lint of 30. The plants are generally allowed to remain in the ground for two or three years, being cut down close to the ground after each crop. Inteiro or Rim de Boi (*G. brasiliense*) is a perennial kidney-seeded cotton. The lint is finer than the former, and is white and strong, with a ginning percentage of 20. The seeds are naked, large and black. The natives prefer this to any other variety for spinning on their hand-spinning wheels. This variety is commonly met with from Para to Bahia. There is also a variety of this type with khaki-coloured lint, but as its ginning percentage of lint is only 18, it is bought at a discount. Quebradinho (*G. purpurascens*) is also a tree cotton. It has a small, naked, black, sharp-pointed seed, and fine glossy lint with a staple of 1 to $1\frac{3}{8}$ inch. This variety is allowed to remain in the ground for three and even five years. Sertanejo Arboreo is a tree cotton similar to that last mentioned.

Cotton Cultivation.—Cotton is generally grown mixed with maize, and sometimes with beans and rice as well, to the detriment of the cotton. The hoe is commonly used to prepare the ground for planting, ploughs being employed to a small extent only. Planting takes place as soon as the rainy season commences. Crop rotation is not practised. Picking begins in June, and generally two pickings are made. The yield varies from 180 to 220 lb. of lint per acre.

Ginning is for the most part very inefficiently carried out with ill-equipped saw gins. The neglect to sharpen the saws seems to be universal throughout Brazil. The gins are driven by means of oxen and apparatus resembling the ancient Persian water-wheel. Much improvement in the crop could be effected by the use of pure seed, better attention to cultivation, and more careful picking.

BAHIA.—The State of Bahia is situated immediately north of Minas Geraes and has an extensive coast line on the Atlantic. Its area comprises 312,512 square miles and its population is three millions. A railway runs through the State connecting Bahia, the capital, with the San Francisco River. The local cotton mills operate some 137,000 spindles and 5460 looms. In the season 1920-21, Bahia produced

9000 bales of cotton and imported 7000 bales for her mills. The 1924-25 crop is estimated at 17,629 bales. The Commercial Association of Bahia employ a classer, who grades all the cotton that comes to the mills, but little regard is given to the length and uniformity of the staple.

Cotton Areas.—The chief cotton-growing districts are : Morro do Chapeo, Bom Jesus dos Meiras Caetete, Pombal, and Patrocinio do Coite. In this State also the best and largest quantity of cotton is grown along the San Francisco River. The principal varieties grown are Quebradinho, Inteiro, Verdao, and an annual type. Verdao also passes under the names of Azulao riqueza, which signifies wealth, and Rompeletras, or debt payer. It has a large seed with bluish-green fuzz, and the lint is strong and silky, with a staple of $1\frac{3}{16}$ to $1\frac{5}{16}$ inch. This variety is said to be a heavy yielder and to produce the best cotton grown in the State. The plant is sometimes left in the ground for several years without being pruned.

Planting takes place after the first rains in October. Picking begins in May ; it is carelessly carried out, and in some cases the trees are shaken and the cotton which falls to the ground is scooped up mixed with leaves and dirt. Much neglect is also shown in the ginning of the crop.

PARAHYBA AND RIO GRANDE DO NORTE.—As regards cotton growing, similar conditions prevail in these two adjacent States. They are situated in the north-east corner of Brazil, with the Atlantic as the north and east boundary, while the States of Ceara and Pernambuco are respectively the west and south boundaries. The area of Parahyba is 28,854 square miles, and that of Rio Grande do Norte is 22,195 square miles. The former has a population of 700,000 and the latter 500,000. From the coast to the interior the country rises by four well-defined steps. Along the flat littoral and for a depth of from 30 to 50 miles is the agreste zone, where the climate is hotter and moister than inland, although it is not so hot and moist as the southern coast of Brazil. Here only annual cotton is grown, and to a small extent. The crop is marketed under the name of Matta. In the foothills or the Matta zone, which is characterised by cactus growth, Quebradinho is grown in dry places, and the annual or Matta type is grown where it is moist. On the

next step, the Catingueira zone, much less annual cotton is found, and Quebradinho is most prevalent. The former is sold as Matta and the latter as Sertao. Here the climate is much drier and rocks and cacti are common.

Tree Cotton.—On the highest step, the Sertao zone, cacti are less abundant; vast stretches are covered with coarse grass and small brushwood, and the country is freely interspersed with boulders. The climate is invigorating. This is the tree-cotton country and annual cotton is rarely seen, but Moco, Verdao, Inteiro, and Quebradinho are all common. The valuable Moco cotton appears to grow best in the Serido region of this zone in Rio Grande do Norte. Because of its high reputation on the market, attempts are made to grow it where the conditions are not so favourable, and where one of the other tree cottons would give better results.

Serido Cotton.—The principal cotton-growing districts in the Serido region are: Acary, Caico, Carraes Novos, Flores, Jardim do Serido, and Serra Negra. The elevation of the Serido region is about 1500 feet. Moco cotton is grown along the margins of the numerous river beds, in the ravines, and on the hill slopes, all of which are enriched by alluvial deposits. An abundance of suitable land is available for cotton growing, but labour is scarce.

Cotton Cultivation.—Little rain falls in this region, and it generally ceases about the beginning of June; the farmers express themselves as perfectly satisfied if they receive about 24 inches. The system of cultivation is most primitive. The use of ploughs is impracticable, owing to the prevalence of rocks, and hoes are the only implements employed. No fertilisers are used. As in most other parts of Brazil, cotton is grown mixed with maize, beans, melons, etc. The cotton trees grow to a great age; some continue to bear for forty years, but fifteen years is generally considered a profitable limit. The plants are weeded once or twice a year. The picking season extends from July to January. After the crop is picked, cows are turned into the fields; they feed on the plants, and this serves the purpose of pruning. At other times the fields are protected with wattle fences.

The substitution of roller gins for saw gins would increase the value of the product, for the lint varies in length from $1\frac{1}{4}$ to $1\frac{3}{4}$ inch. The ginning percentage of lint is 26. At

present there are no modern ginning factories in the Serido. Every bale of cotton is branded with the name "Serido". In normal seasons the crop amounts to 70,000 bales of 143 lb.

Sertao Cotton.—In the remainder of the Sertao zone the conditions of cotton production resemble those already described. Seed is sown in January or February at a distance of 7×5 feet. The growers argue that it is unnecessary to clear away the coarse grass around the plants, because when the cotton falls upon the grass it does not become dirty, as is the case when it falls upon the cleared ground! The yield is reported to amount to from 310 to 320 lb. of lint per acre.

Campina Grande is the great interior cotton market in North Brazil; 200,000 bags of 143 lb. each are received each year, and these are despatched by railway to Pernambuco and Parahyba. The cotton merchants of this place often make advances to the small growers, and buy cotton before it is harvested. Generally they buy according to locality and do not examine the cotton; it is thus a simple matter for lower grade cotton to be sent to Serido for baling and sale as Serido cotton.

SERGIPE.—This is the smallest State in the Union; its area is 15,090 square miles and its population is 450,000. It is triangular in shape, and is bounded on the east by the Atlantic, on the west by Bahia; in the north-east it is separated from the State of Alagoas by the San Francisco River. The coastal region is low-lying, but plateaux and mountainous country occur farther inland.

The principal cotton-growing districts are: Nossa Senhora das Aores, Propria, San Paulo, and Annopolis. It is estimated that in the season 1924-25 a total crop of 23,221 bales, each weighing 500 lb. of lint, was produced on an area of 57,110 acres, which gives an average yield of 203 lb. of lint per acre. The eight local mills, with their 52,000 spindles, consume practically the whole crop. The State's export tax of 8 per cent seems likely to prove a check on the more extensive cultivation of cotton.

Verdao, Inteiro, and Quebradinho are the varieties most commonly grown. The first mentioned is preferred, and it is generally left in the ground for four years, but it is pruned after the second crop. Planting is done in February and

March, and picking begins in August. The cotton produced is strong and white, with a staple of $1\frac{1}{8}$ inch.

ALAGOAS.—This is the second smallest State next to Sergipe; it has an area of 22,580 square miles and a population of 800,000. It has a frontage on the Atlantic, and is bounded on the north by the State of Pernambuco. Sugar is the principal crop, but cotton is grown in twenty-six of the thirty-five municipalities. There are ten cotton mills operating 50,000 spindles. Heavy export taxes are also likely to prove a deterrent to more extensive cotton cultivation in this State. The varieties of cotton grown are similar to those grown in Sergipe, but planting is done in May and June. The average yield is given as 194 lb. of lint per acre.

PERNAMBUCO.—This State has a long coast-line on the east. It has an area of about 50,000 square miles and a population of 1,300,000. Pernambuco or Recife is the principal port, and it is also the nearest Brazilian port to Europe, being about 4000 miles distant from England. This State has large possibilities for cotton production, but at present most of the cotton exported from Recife is grown in the neighbouring States. Sugar is the principal crop, and cotton ranks second in importance. The cotton crop of the season 1924-25 is reported to have exceeded 75,600 bales.

The chief cotton-growing districts are: San Jose do Egypto, Correntes, Flores, Timbauba, Bom Jardim, Garanhuns, Gloria do Goyta, Limoeiro do Norte, Nazareth, Alfogados de Ingazeiro, Brejo da Madre de Deus, and Taquaretinga. Moco, Verdao, Quebradinho, and an annual type are the kinds of cotton most commonly grown. Verdao is the most popular variety. The State has granted a concession to a ginning company on condition that it distributes seed of Verdao free of charge to planters in the Garanhuns district. The Government appreciates the cotton-producing possibilities of the State, and has established a Cotton Service to instruct farmers, establish seed farms, investigate pests, and improve the conditions of ginning and baling the crop. Proposals are also under consideration for the institution of a Produce Exchange with a qualified Cotton Classifier.

CEARA.—This State is situated in North-east Brazil; it has a coast-line of 300 miles on the Atlantic, and joins the

States of Rio Grande do Norte and Parahyba on the east, and Pernambuco and Piauhy on the south and west respectively. Its area is 40,247 square miles, and it has a population of 1,300,000. The climate is hot and dry; January is the normal rainy month, but often the rains do not arrive until after the equinox in March. The mean annual rainfall is 47 inches, but in years of drought less than 12 inches are received. The rains are badly distributed, for too long intervals occur between successive falls; moreover, as a great deal of the rain falls in a short period of time on the dry, impermeable soil, the water rushes away into the river beds and is lost in the sea. There is no perennial river, owing to the rapid slope of the mountains towards the sea. Droughts are common in periods varying from five to seven years, and cause serious famines. It is estimated that during the drought of 1915-16 a million cattle perished.

There are two main lines of Government railways: one runs from the capital, Forteleza, southwards for almost the length of the State, with connections to Parahyba; the other traverses the State southwards from Camocim.

Cotton is the principal crop, followed by sugar and coffee. In 1920 the export duty on cotton amounted to 1 per cent *ad valorem*. The area under cotton cultivation is estimated at 201,800 acres. There are eight cotton mills in Ceara, with 24,000 spindles and 540 looms. Most of the spindles turn out a coarse yarn that is used for weaving hammocks on handlooms, these hammocks being largely used locally in place of beds.

Irrigation Projects.—The construction of railways, roads, and reservoirs is being pressed forward. The reservoirs are not only intended for the supply of water for domestic purposes, but for irrigation as well. Wherever possible, farmers have erected small reservoirs themselves. In view of their probable stimulus to cotton production, some of the chief irrigation projects may be briefly considered.

Acarpe Reservoir.—This project consists of a masonry dam for conserving the Pacoty River. Work on it was commenced in 1910; it has not been continuous, but it is now practically completed. The anticipated volume of water to be collected is $2\frac{1}{4}$ million gallons. The dam is situated 52 miles south of Forteleza, and its principal object is to

supply water for that town, but it is expected that water will be available for irrigation as well.

Cedro Reservoir.—This reservoir is situated close to the town of Quixada. The masonry dam across the river was completed in 1906. The hydraulic basin has a capacity of 33,729 million gallons. The greatest volume of water so far collected was 30,000 million gallons in 1917. The area available for irrigation is 5000 acres, but so far little more than 300 acres have been regularly irrigated, and cotton has not been grown. The district, however, produces about 16,500 bales of cotton per annum.

Patu Dam.—This project was commenced in April 1921, the objects of the masonry dam being to convert the Banabuihu, a tributary of the Jaguaribe, into a perennial river, and to form a reservoir of 52,800 million gallons capacity.

Oros Dam.—This project was commenced in March 1922, and is reported to be the largest reservoir under construction in the world. It has for its object the holding up of the waters of the Jaguaribe River by means of a wall 164 feet high. The catchment basin covers an area of 6,770,540 acres, with a reservoir capacity of 792,000 million gallons. When it is completed, it is anticipated that the Jaguaribe Valley, and especially the lower portion where the land is level and the soil is deep and fertile, will be devoted to irrigated cotton cultivation. The districts that will benefit by the irrigation will be: Ico, Jaguaribe-mirim, Riacho do Sengue, Limoeiro, Morada Nova, Russas Uniao, and Aracaty. The Oros Reservoir is expected to irrigate 148,000 acres, while the Quixeramobim and Poco dos Paus projects, also in the Jaguaribe Valley, are expected to irrigate 44,500 acres and 54,400 acres respectively. Some of these districts already produce a considerable quantity of cotton. Morada Nova has an output of 3000 country bales, Ico 2000 bales, and Limoeiro 9900 bales. Other important cotton-growing districts in the State are: Iguatu, which produces 5500 bales, and Crato, 1650 bales.

Cotton Cultivation.—The chief varieties in use are Quebradinho, Herbaceo, Verdao, Inteiro, and Moco. Maize and beans are generally grown in the same field with the cotton. The average yield of the cotton is reported as 190 lb. of lint

per acre. The hoe is the only agricultural implement in use, and fertilisers are not applied to the land.

Ceara cotton is badly picked, and it is usually dirtier than that from other parts of Brazil; moreover, it frequently suffers through being unduly exposed to the weather. The lint is uneven in quality, owing to the circumstance that at least five kinds are usually grown mixed together, and sufficient care is not devoted to ginning. The staple varies in length from 1 to $1\frac{1}{8}$ inch.

Ginning and Baling.—Most of the ginning is done by the means of small saw gins, usually with 35 saws each, which are often badly housed, and are generally neglected. In the country districts baling is done with hand-screw presses. A bale of 250 lb. is made when the press is situated near the railway, but in the interior, from whence bales are transported slung one on each side of the back of a mule, a bale of 150 lb. is usual. In order to economise canvas, 7 or 8 inches of the bale is left uncovered, with the result that much cotton is lost by the time that the bale reaches its destination, especially when the mules travel through rough, bushy country; and besides, the cotton suffers from exposure to the weather and dirt.

The crop is mostly grown by small farmers, and to a less extent by tenants of large landowners; in the latter case the landlord receives a share of the crop in lieu of rent. The ginner may buy the crop on his own account or for the large exporters; often the latter advance as much as 40 per cent, against a written contract, on the cotton in the field; when this is done the crop is handed to the lender, or as much as 12 to 15 per cent interest is paid on the loan. Some growers transport their cotton to the market town and store it with one of the merchants, and receive an advance from him; if he does not eventually buy the cotton, he profits by charging rent, fire insurance, and interest.

Market Conditions.—Merchants buy the cotton according to its cleanliness, paying about 1d. per lb. premium for clean cotton. Their classification is: Premeiro = clean cotton, Mediano = dirty cotton, and Refugo = very dirty cotton. Generally 60 per cent is classed as Mediano, 30 per cent as Premeiro, and 10 per cent as Refugo. In the absence of a demand for cotton, arbitrary methods are adopted,

and clean cotton then ceases to exist! The merchants do little to encourage clean picking, careful ginning, and baling.

At the export houses the country bales are opened and the cotton is shaken over frames covered with $\frac{3}{4}$ -inch wire netting. This process virtually converts the Mediano to Primeiro! The cotton is rebaled in hydraulic presses into bales weighing 308 lb., measuring $3.28 \times 2 \times 1.6$ feet, and with a density of 29.3 lb. per cubic foot. The export houses sell under two or three different marks representing (a) Best, (b) Primeiro, and (c) Mediano. The exports go to Liverpool, Rio de Janeiro, and also to Mossoro in the State of Rio Grande do Norte.

MARANHAO.—The State of Maranhao is 177,560 square miles in area and it has a population of 800,000, including many uncivilised Indians. It is bounded on the north by the Atlantic for a distance of 394 miles, and on the east, south, and west by the States of Piauhy, Goyaz, and Para and Goyaz respectively. It is well supplied with rivers, the following being navigable: Tury Assu, Mearim, Pindare, Paranahyba, Tecantins, and Ilapecuru. For the most part water is the only means of transport. A narrow-gauge single line of railway, 280 miles long, extends from the capital, San Luiz, to Therezina in the State of Piauhy. San Luiz is situated on an island, and the projected bridge to connect it with the mainland is not yet built. From a cotton-producing standpoint this railway is of importance, as it taps the vast interior cotton-growing uplands known as Sertao. The climate is hot and moist, the average temperature at San Luiz being 79° F. The rainfall is 81 inches, and the rainy season extends from December to June.

Cotton Cultivation in Seventeenth Century.—Cotton was abundant in Maranhao early in the seventeenth century, and it has been exported since 1760. Maranhao cotton was well known and appreciated in Liverpool more than fifty years ago. As long ago as 1877, 55,884 bales of 220 lb. in weight were exported. To-day the total production is over 70,300 bales of 500 lb. At present the exploitation of the recently discovered babassu oil nut, the product of an indigenous palm that occurs in vast numbers, promises to be a serious deterrent to cotton cultivation. There are 71,600

spindles in the mills of the State, and these consume about 24,000 bales.

Cotton Areas.—The most promising cotton-growing districts are the valleys of the rivers Paranahyba and Pericumán, and along the coast where the soil is dark-coloured. The hot, moist climate and heavy rainfall conduces to a luxuriant growth of weeds; consequently after the cotton is picked it is usual to abandon the site, for it is found more economical to burn down and clear a new one than to keep the old one weeded. As the old cotton plants are not eradicated, they function as a nursery for disease and pest propagation. A mixture of varieties is grown similar to that found in Ceara. The Federal Cotton Service has established an experimental cotton farm at Coroata, but little benefit has accrued therefrom owing to lack of funds, while the results achieved have been vitiated by the theft of the crops.

Handling the Crop.—There are over 200 gins in operation in the State. Cotton grown in the interior arrives on the market in bales of various sizes and shapes, from small parcels wrapped in palm leaves to bales of 440 lb. in weight; lianas cut from the forest are almost invariably substituted for metal bands, so that 4 per cent is deducted for tare. Baling is carried out in the Government warehouse by hydraulic press, and a charge is made for classing, warehousing, and baling, plus an export tax of 10 per cent *ad valorem*. The average weight of these bales is 240 lb. By decree of 21st August 1920, all cotton for shipment must be officially weighed. After official classification, it is stored in Government warehouses. Two classes are recognised with three types in each class. Actually the classification is in respect to clean and dirty cotton, with only slight regard to length of the staple, while the strength of the fibre receives no attention. Cotton for export requires a certificate from the official classifier, and to be marked with its class on each bale.

PIAUHY.—The State of Piauí is surrounded by the States of Ceara, Pernambuco, Maranhão, and Bahia. It has an area of 116,523 square miles, with a population of 485,000. It possesses no railway, and practically all traffic passes along the Paranahyba River. Much of the cotton produced in the State is conveyed through Maranhão.

The principal cotton-growing districts are: Buritz dos

Lopes, Therezina, Uniao, Amarante, Porto Alegre, Parahyba, and Marruas. During the two seasons 1920-21 and 1921-22 the amount of cotton produced was estimated at 7480 bales and 5280 bales of lint respectively, the bale weight being equivalent to 500 lb. In 1924-25 the crop amounted to 17,600 bales. The pink boll-worm is very prevalent, and its ravages seriously discourage the growers. No modern ginning outfit exists in the State, but there are over forty small ginneries. One high-density press has been installed in the town of Parahyba. The whole of the crop is exported, with the exception of a small quantity consumed in a mill of 2600 spindles in the capital, Therezina. The conditions of cotton cultivation resemble those prevailing in the adjoining States.

PARA.—The State of Para has for its boundaries the Atlantic and French Guiana on the north, Maranhao and Goyaz on the west, Matto Grosso on the south, while the eastern boundary is at present undefined. Its area comprises about 443,903 square miles, of which about one-third is still unexplored; its population is 925,000. It possesses 700 miles of coast line. The capital, Para (Belem), is situated 86 miles from the sea, but it has an excellent port. Only one railway exists, and this runs from Para to Bragansa, a distance of 145 miles. Owing to the ramifications of the Amazon and its tributaries, the need for more extensive railways has so far not been seriously felt. It is interesting to note in this connection that Para possesses a considerable number of islands, some of which are extensive, one, at least, being larger than Switzerland. On these islands a good deal of cotton is grown to supply yarn for the manufacture of hammocks.

The State may be divided into three zones: the plateau of Guiana in the north, the Amazon Valley in the centre, and the tableland of Brazil in the south. Early in the nineteenth century cotton was grown to a considerable extent, and in 1817 over 13,000 bales were exported.

Failure of Rubber Industry.—The Para rubber industry has been ruined by the development of the rubber planting industry in Asia, for although rubber is collected from wild trees in Para, the cost of collection and transportation is high. The production of even ordinary foodstuffs has been

neglected, so that everything had to be imported. The cultivation of rice and maize is now being re-established, and to-day sufficient rice is grown for local requirements and a small quantity for export as well.

The climate is similar to that of Maranhao, and the cotton produced is similar to Maranhao cotton. The total production of cotton has now reached 7000 bales of 500 lb. in weight. This is grown in three different areas : (1) situated east of Para, which includes Bragansa and the district of Igarape-Assu ; (2) the Lower Amazon district, with the towns of Santarem and Monte Alegre as centres ; and (3) the islands, including Breves Gurupa and Macapa. In the first two mentioned areas, Upland is grown mixed with Verdao and Inteiro. It is planted from January onwards ; the plants are generally left in the ground for two seasons, but are pruned after the first crop has been harvested. In the islands, only Inteiro is grown. This cotton has a ginning percentage of lint of only 18 to 20, but the lint is strong, though coarse, and has a staple length of 1 inch. Various firms in Para and Santarem have established gins and presses for handling the crop, which is mainly exported to Rio de Janeiro or Oporto.

SUMMARY.—That the soil and climatic conditions of many parts of Brazil are admirably adapted for cotton production is testified by the high yields obtained, which are comparable with those of any other cotton-growing country in the world, and, moreover, these have been secured without the aid of irrigation and with no scientific plant breeding or seed selection.

The areas suitable and available for cotton growing are larger than the United States cotton belt, and for the most part are situated inland, where the conditions of life are much healthier than those obtaining on the coast.

The cost of land and wages is low as compared with that prevailing in such cotton-growing countries as the United States and Egypt, and so long as the price of cotton is in the neighbourhood of 10d. per lb. it can be produced at a profit.

As regards the labour supply, the collapse of the rubber industry and the decreased demand for coffee has caused increased attention to be devoted to cotton, while the United States immigration restrictions and the political unrest in

Europe has attracted an increased number of immigrants to Brazil.

For the more rapid extension of the industry, capital is much needed for the development of land and irrigation schemes, financing organisations for the more efficient handling and marketing of the product, and the provision of improved transport.

Above all, experts are needed to aid in the guidance of those engaged in the industry. The principal defect in the lint is the lack of uniformity, due to variety mixture. The removal of this defect is of cardinal importance, and this can be best achieved by the establishment of Experiment Stations for testing existing varieties, and raising new types to provide adequate supplies of pure seed of those kinds that can be most profitably cultivated in particular areas. In this connection the various companies that have recently been formed for the purpose of growing cotton in Brazil could render invaluable assistance by growing large areas of the varieties selected by the Stations for the supply of pure seed to the smaller growers.

BRAZILIAN COTTON PRODUCTION IN 1924-25 BY STATES
(ESTIMATED)

States.	Area Planted (acres).	Average Yield of Lint per acre (lb.).	Production of Cotton (Lint) (Bales of 500 lb.).
San Paulo	341,675	227	155,282
Ceara	201,888	215	88,064
Minas Geraes . . .	95,970	198	76,623
Pernambuco	184,350	205	75,600
Maranhao	157,685	223	70,302
Parahyba	171,868	204	70,229
Rio Grande do Norte .	163,075	209	68,141
Alagoas	76,393	194	29,719
Sergipe	57,110	203	23,221
Bahia	46,455	191	17,629
Piauhy	52,175	170	17,600
Para	23,820	145	7,128
Parana	5,825	151	1,761
Goyaz	4,215	135	1,113
Rio de Janeiro . . .	3,600	126	912
Espirito Santo . . .	3,125	116	727
Amazonas	1,160	212	492
Total	1,590,389	221.5	704,543

CHAPTER VII

COTTON PRODUCTION IN CHINA AND RUSSIA

CHINA.—Cotton production and consumption—Cotton areas—Cotton cultivation—Kinds of cotton grown—Intensive cultural methods—Short growing season in N. China—Cotton yields—Adulteration—Insect pests and diseases—Ginning and baling—Cotton manufactures.

RUSSIA.—Cotton growing an ancient industry—Cotton-growing areas—Cotton cultivation—Turkestan—Trans-Caucasia—Cotton production in Russia.

CHINA

Cotton Production and Consumption.—The Chinese did not commence to make use of cotton to any great extent until the fourteenth century, but latterly its production and consumption in China has assumed enormous proportions. It is now the third largest cotton-producing country in the world, and has an estimated production of about two million bales of 500 lb. in weight. Unfortunately authentic statistics are not available. The Chinese Ministry of Agriculture estimated the average annual production for the years 1909–1911 at over four million bales, but this estimate is probably too high. The Chinese Millowners' Association estimated the crop for the season 1922–23 at 2,188,880 bales.

The Department of Commerce, United States, estimate Chinese cotton production in recent years as follows :

	Bales of 500 lb.
1919	1,150,000
1920	1,045,000
1921	1,030,000
1922	1,360,000
1923	1,420,000
1924	1,862,000 (estimated)

During the period 1919–21 China's average annual exports of raw cotton amounted to 183,000 500-lb. bales, 70 per cent

of which went to Japan ; but these exports are not necessarily indicative of a surplus, for during the same period she imported 203,000 bales of raw cotton, while in 1923 she imported 306,000 bales from the United States and 19,000 from India. It is of course possible that some of this cotton was of a quality that is not produced in China in sufficient quantity to supply the local demand.

Cotton Areas.—Cotton is grown more or less in every province, but principally in the Central and Northern regions. The chief cotton-growing tracts are : (1) The basin of the Yangtse River ; here the best cotton is grown in Tungchow and Taichong, both in the Kiangsu Province, and are respectively situated north and south of the Yangtse estuary. (2) The basin of the Hoang-ho or Yellow River, particularly in and adjacent to Chanteh in Honan Province. (3) The Province of Chekiang, more especially near Ningpo and Shaohingfo. A good deal of cotton is also grown in Yunnan in Western China, near Burma.

In 1921 the principal provinces where cotton was grown for market were :

Province.	Crop (Bales of 500 lb.).	Province.	Crop (Bales of 500 lb.).
Chihli . . .	484,000	Kiangsu . . .	342,000
Hupei . . .	164,000	Shensi . . .	115,000
Chekiang . . .	82,000	Shantung . . .	82,000
Shansi . . .	66,000	Honan . . .	59,000
Anhui . . .	44,000	Kiangsi . . .	12,000

Cotton Cultivation.—The cultivation of cotton has received a considerable impetus from the prohibition of opium cultivation, and the interest taken in the matter by the Chinese Cotton Millowners' Association, the Cotton Anti-adulteration Association of Shanghai, and the Bureau for the Improvement of the Cotton Industries. Other contributory factors have been the increased demand for Chinese cotton from abroad, more especially from Japan, and the successful efforts of the dealers to check the watering of cotton, and improved cotton prices. Notwithstanding the extensive increase in cotton cultivation that has taken place, it is doubtful whether China will do much more than supply her own and Japan's requirements for some time to come ; however, considering China's enormous population, estimated at over 400 millions, and

the enormous areas available for growing the crop, it is conceivable that with more stable government her cotton production will ultimately largely increase.

Kinds of Cotton grown.—The principal Chinese commercial cottons belong to *G. Nanking*, Meyen, the khaki-coloured fibre being the true Nanking cotton. The plant is delicately formed; frequently with purplish twigs and leaf stalks, and all parts are covered with shaggy hairs. The imperfectly cordate leaves are pale green in colour. The flowers are axillary and solitary, large, yellow coloured with faint purplish claws. The capsules are angled and 3-4-celled. The seeds are large, densely coated with rust-coloured fuzz, and bearing silky, white lint, which tends to become khaki or reddish coloured.

Two kinds of cotton are grown in North China. In the Chihli Province that known as Hsiho is grown in large quantities. The staple resembles Peruvian cotton; it has a good colour but is short and wiry, and is unsuitable for spinning yarn. It is therefore largely exported to the United States for mixing with wool, and to Japan for stuffing kimono, etc. North of Tientsin, in the Shantung Province, a better grade of cotton known as Yuho is grown, which is suitable for spinning low counts. Some of the cotton grown in the Yangtse Valley is likewise too short for spinning purposes. That grown in the lowlands of Honan is strong, but short in staple, and it is only used for spinning low counts.

In the region around Nanking, and since 1915, a certain amount of success has been attained in the improvement of Chinese cotton by the introduction of American varieties, and the establishment of cotton experimental stations, where plant selection work has been undertaken. American cotton experts have been engaged to investigate and advise as to the best measures to adopt in this connection. A great deal of experimental work has been conducted both with the native and American cottons. The former appear to be best adapted to the coastal area, while the latter promise best in the Yangtse-kiang and Hoang-ho valleys.

It was observed that practically all the cotton fields inspected contained a mixture of varieties, though the Upland plants exhibited the widest variations, many of them being of an inferior character. Certain coastal areas were

marked out as characterised by the growth of superior native kinds. The American Upland variety Trice was re-introduced, and within three years the work of acclimatisation had so far been accomplished that large quantities of stabilised pure strain seed were available for despatch to selected centres to form the nuclei of one variety cotton communities. In this work much valuable assistance was rendered by an army of carefully drilled students under trained teachers and professors from the various universities in the country. Some 1500 separate Upland plants were selected, labelled and studied in detail; 650 progeny rows were grown, and studied; and 37 multiplication fields were separately picked, sampled, and ginned.

As regards the selection and fixing of superior strains of native cottons, hundreds of fields were examined and over 1000 individual plants were marked and studied. Some 300 were selected and grown in progeny rows; from these 40,000 selections were separately studied, and a further 1500 progeny rows were grown from the best plants. A number of native strains have been selected for multiplication and distribution.

The climate is dry in the north but wet in the south. In the Yangtse Valley there is usually ample rain for cotton, but the farmers safeguard themselves from drought by irrigation. The soil varies from heavy clays to sandy loams.

Intensive Cultural Methods.—Pasturable pursuits are of quite secondary importance to the Chinese agriculturist, except in Central China, where the Yellow River floods and renders large tracts of land unfit for cultivation. Chinese agriculture is, of its kind, magnificent; the land is made to yield extraordinary results and to bear two or three crops a year. There is no wastage; through long experience, the farmers have learned to anticipate some of the most recent western scientific discoveries as regards conserving and recuperating soil fertility. The result is that the land appears to have been raised to its highest level of productivity.

Land is rented in many cases on a system of return in kind to the landlord, according to the harvest, at a fixed percentage on the yield. The farmers are poor, ignorant, and conservative; their holdings are small and are frequently not more than half an acre in area. The means at their disposal

do not permit of expenditure on imported fertilisers. Ploughing is done with a two-handed wooden plough, which is tipped with iron or steel, and is drawn by oxen or buffaloes.

When the ground has been prepared, wheat is sown broadcast, and a light dressing of liquid manure is given. The wheat is nearly ready for reaping about the middle of May, and at this period cotton seeds are dropped between the haulms and covered with soil. This system of broadcast sowing is one of the limiting factors in Chinese cotton production, for it involves unnecessarily laborious hoeing operations. Sometimes the seeds are soaked in water and then rubbed in wood ashes before being sown. At the end of May the wheat is reaped, leaving the haulms a few inches higher than the cotton. Any vacant places are resown with cotton seed, and a dressing of liquid manure made from night soil is given.

When the cotton seedlings are about 6 inches high, they are thinned out to 7 or 8 inches apart, and the ground is hoed and the soil is drawn around the plants. Weeding and hoeing is continued at intervals as required during the growing season. The plants begin to flower in July and the bolls mature at the end of August, or early in September. Picking continues until the first week in October, but in late seasons it may even last until November. The practice of picking the entire boll and extracting the cotton afterwards still prevails in many interior districts. Chinese cotton is usually carefully picked, and is freer from leaf and dust and also whiter than Indian cotton.

Sometimes a third crop in a year is obtained by sowing beans among the cotton plants in the middle of October. The cotton plants are removed after harvest and the beans occupy the ground through the winter. The beans are harvested in April, and the plants are ploughed into the ground as a fertiliser for the succeeding crop.

Rice may be grown instead of wheat; in this case the ground is covered with water before the rice is sown. The rice is harvested in September and the haulms are ploughed into the ground for wheat.

Short Growing Season in North China.—The principal obstacle to cotton growing in North China is the short growing season due to early frosts; while the soil is also less fertile than that found in the Yangtse Valley. In North China cotton

seed is planted broadcast early in May. Plant thinning takes place a month later, and picking begins in October and lasts until the frosts arrive. Two kinds of fertiliser are used. The one in most general use consists of human excreta diluted with water, which is distributed over the fields by hand with a long-handled ladle, either just before planting or during the growing season. The other consists of cotton-seed cake and bean cake, broken into pieces about half an inch square ; these are placed in the soil by hand near the roots of the plant.

In the Yangtse Valley, mud from the irrigation canals is mixed with ashes and spread over the ploughed fields before the seed is sown.

It is considered that better cotton yields would be obtained if the planting were done earlier ; the farmer is, however, disinclined to risk injury to his wheat crop by adopting this procedure, so that the obvious remedy is to plant the cotton separately. It is probable that the night soil and cake used as a fertiliser contain too much nitrogen and too little phosphoric acid, which is conducive to strong plant growth at the expense of fruit production.

Cotton Yields.—The estimates of the yield of seed cotton per acre show great variation. Where cotton is grown alone on good land it is said to yield as much as 1000 lb. of seed cotton per acre, but only 680 lb. when grown along with another crop. In the Yangtse Valley the average yield is given as 480 lb. of seed cotton per acre. The ginning out-turn varies from 30 to 35 per cent of lint. As regards length and fineness, the best cotton is grown in Taichong and Tungchow ; this lint has a staple length of $\frac{3}{4}$ inch. Shanghai cotton ranks next with a staple of $\frac{5}{8}$ inch, but is not so fine.

Adulteration.—The practice of watering cotton has always been a serious cause for complaint, but it is not so prevalent as hitherto. In 1895 Japanese spinners decided to buy only from approved dealers, who were associate members of the Japanese Cotton Spinners' Association. Testing-houses were established at all ports, and cotton containing excessive moisture is rejected. Another fraudulent practice is the mixing of seed cotton with lint, which causes serious inconvenience at the mills.

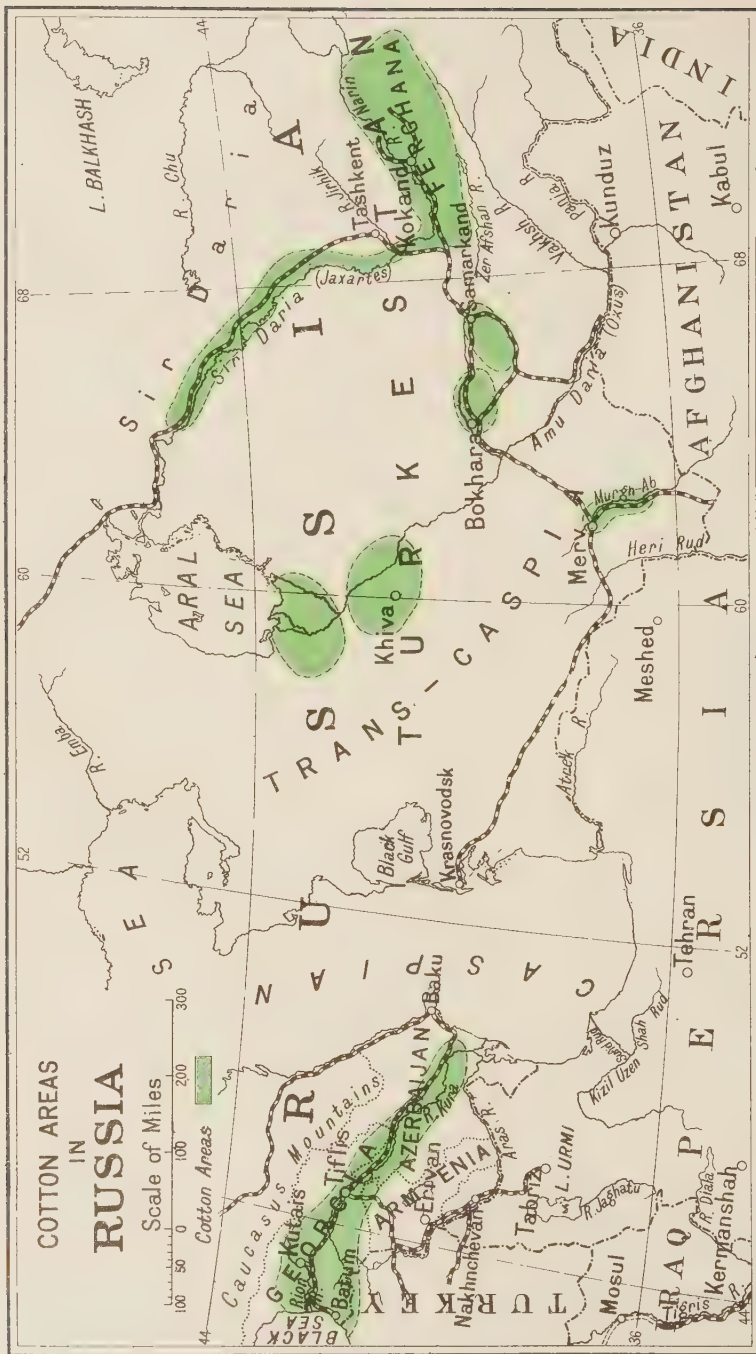
Insect Pests and Diseases.—The prevalence of insect pests and fungus diseases also presents a serious obstacle to

successful cotton cultivation in China. The pink boll-worm is common as well as other boll-worms, leaf hoppers, leaf rollers, cut-worms, red spider, and plant lice. The diseases most prevalent are : Rust, Anthracnose, Boll Rot, and Leaf Curl. The bacteriological disease known as Black Arm is also common. It is considered that the reported proneness of American cotton to disease has been unduly exaggerated.

Ginning and Baling.—Cotton is still ginned by hand in some of the interior districts. Small foot gins are in use which only produce about 26 lb. of lint in a day. Of recent years, large numbers of Japanese hand gins of the Macarthy roller type have been imported. All farmers with sufficient means own a ginning machine and gin their cotton before marketing it. Some of the roller gins in use weigh 70 to 100 lb. and are operated by hand or steam power, and have an output of 150 to 200 lb. of lint in a day of eleven hours. At large centres, such as Shanghai, well equipped steam-power ginning outfits are in operation. One disadvantage attaching to the introduction of American cotton is the circumstance that the roller gins used for ginning the native cotton will not gin the American cotton.

After ginning, the lint is packed, in quantities varying from 75 to 250 lb., in bags made of bamboo strips, or of coarse Nanking cloth, which is made on hand-looms. These bags of lint are despatched by coolie or on small junks by the rivers and canals to Shanghai, Hankow, or Tientsin, where it is hydraulically compressed into bales, of from 466 to 533 lb. in weight, measuring 12 cubic feet and with a density of 41 lb. per cubic foot. These bales, both in appearance and density, compare favourably with those from many other parts of the world. Many foreign firms send representatives into the interior to buy up cotton in small lots from individual farmers, and then despatch it in bulk to the chief consuming and exporting centres.

Cotton Manufactures.—The lint of the indigenous cotton is generally coarse in quality and cannot be spun in counts finer than 20's. By far the larger portion of the crop is worked up in the homes of the natives. Native looms are found in most houses ; mills have only been erected within the last twenty-five years. Shanghai is the chief centre of the manufacturing industry. In 1923 there were in China 119 cotton



mills, nearly 6 million spindles, and 22,477 looms. The total annual production of Chinese cotton mills amounts to from 200 to 250 million pounds of yarn, and from 50 to 60 million yards of cloth. Practically all the mills run day and night on a twenty-three-hour schedule. The growth of the cotton industry is one of the most outstanding developments in China of recent times, and the possibilities of further development are enormous, for the bulk of the population of over 400 millions is clad in cotton clothing.

Although much of the raw cotton which is exported to Japan is returned again in a manufactured state, it is to be observed that the Chinese manufacturing industry is a comparatively recent development, and in course of time will probably be able to manufacture the goods that are at present imported from Japan, for China produces the raw material, whereas Japan is dependent on imports. In addition to its proximity to the source of the supply of the raw material, labour is very cheap and plentiful, and coal for power purposes can be obtained at low rates both from the native mines and also from Japan. During recent years there has been a marked decrease in the importation into China of the cheaper grades of cloth as well as of yarn.

Outside the British Empire, China is Lancashire's best customer for cotton goods. It is estimated that in 1924 the value of cotton piece goods from English mills, imported through Hong-Kong, was over £3,000,000. It is, however, noteworthy that in the thirteen years to 1924, Great Britain's share of the China market for cotton piece goods has declined from 61·8 per cent to 35·73 per cent.

RUSSIA

Cotton Growing an Ancient Industry.—Cotton has been grown in Turkestan from ancient times. The native cotton, *G. herbaceum*, is similar to Indian cotton; it is rough in staple and about $\frac{7}{8}$ inch long. It also resembles the Indian Wagad variety in respect of the bolls, which do not open sufficiently to permit the cotton to be readily picked, so the bolls are plucked, and the cotton is extracted afterwards. China cotton, *G. Nanking*, has been grown in Trans-Caucasia since very early days. As in many other countries, the cotton

famine at the time of the American Civil War encouraged the extension of cotton cultivation and the introduction of new varieties. American Upland varieties proved most successful, and this type of cotton soon became acclimatised and quickly gained in favour on account of its superior quality and higher yield.

The extension of cotton growing was greatly assisted by the imposition of a high import duty of 3·7d. per lb. on all imported cotton. However, until the outbreak of the Great War of 1914, Russian mills still continued to consume annually half a million bales of imported cotton, chiefly of American origin, in addition to practically the whole of the Russian crop.

In 1913 the Russian cotton crop was estimated at a million 500-lb. bales. In that year there were over 9 million spindles operating in Russian mills, which was an increase of about 50 per cent on those operating in 1900. As during this period the imports of cotton remained fairly stationary, the increased demand was met by the locally grown staple. In 1916 it was estimated that the area under cotton had increased to nearly 2 million acres and the crop to approximately 1,160,000 500-lb. bales of lint, but five years later the area under cultivation fell to one-tenth of that planted in 1913. The decrease was of course mainly attributable to the unsettled condition of the country brought about by the late war. The circumstance that a large quantity of the crop is absorbed for domestic consumption, of which no statistics are available, renders an accurate estimate of the crop impracticable.

Cotton-growing Areas.—The two principal areas that produce the crop are Turkestan and Trans-Caucasia. The former is situated on the east of the Caspian Sea, north and west of the Himalayas, and south of 43° N. lat. The latter lies between the Caspian Sea and the Black Sea. It is interesting to observe that, with the exception of some districts in China and Korea, these are the two most northerly cotton-growing areas in the world; they are at least 5 degrees farther north than any portion of the American cotton belt, while no cotton is grown so far distant from the equator in the southern hemisphere.

The climatic conditions prevailing in these two regions

are somewhat similar. Owing to the intense heat in summer, evaporation is extremely heavy. In Turkestan the rainfall ranges from 6 to 16 inches, and is slightly heavier in Trans-Caucasia. Cotton production is therefore only feasible under irrigation, which is rendered possible by the presence of numerous rivers. Hot dry winds in the summer, that sweep over the desert from the north and north-west, are the most inclement feature of the climate. Their desiccating effects on the plants cause much damage, while they injure the ripe cotton by soiling it with dust and trash.

Cotton Cultivation.—Irrigation was originally introduced in the first century by the Chinese, who formerly grew cotton in Turkestan. The Russian Imperial Government resuscitated the industry, encouraged the extension of the irrigated areas, and imported large quantities of American cotton seed. Where this seed has been kept pure, the staple is $1\frac{1}{8}$ inch, but in many cases it has suffered deterioration through hybridisation with the native cotton.

Planting takes place in March and April; the picking season begins in August and terminates with the arrival of frost in October. It therefore follows that the use of early maturing varieties is essential. Comparatively high yields are obtained, varying from 300 to 450 lb. of lint per acre. An implement resembling the Indian "Churka" is used for ginning in the country districts, but in all the principal cotton-growing centres modern ginneries have been erected. The ginning out-turn ranges from 28 to 30 per cent of lint. Formerly the lint was made up into bales of 250 lb., but latterly the 500-lb. bale has become popularised.

Turkestan.—The principal cotton-growing districts of Turkestan are: Ferghana, Sir Daria, Samarkand, the Trans-Caspian Territory, and the tributary states of Bokhara and Khiva. In this region the soils are rich and their fertility is increased by alluvial deposits from the rivers. The land is mostly in the hands of small farmers, and is either owned by them or is hired on a profit-sharing system. Most of the work is done by hand labour. After the land has been watered, cotton is planted on ridges, and as many as twenty to thirty seeds are planted in one hole in order to assist the young plants to break through the compact crust formed by the stiff soil. The plants are thinned out to three in a stand.

During the growing season the crop receives four or five irrigations.

Ferghana is the most important cotton-growing district. Originally it produced about one-half of the whole Russian cotton crop, and almost entirely of the American type, of good white colour, and strong, silky staple about $1\frac{1}{8}$ inch in length. This district is situated in a long valley, which is bordered on three sides by high mountains, and is irrigated by canals from the Sir Daria River. In Samarkand the value of the American cotton grown is much depreciated by its admixture with native cotton. The Imperial Estates were situated in the Trans-Caspian region, and these were admirably laid out on the Murgab River, and produced excellent cotton. Elsewhere in this region the crop has suffered through the admixture of varieties. In addition to the Murgab, this region is likewise irrigated by the Amu Daria, the classical Oxus.

Formerly only native cotton was grown in Bokhara, because of the circumstance that the land tax was assessed on the value of the crop, and it could not be removed from the field until it had been inspected and valued by the revenue officer. As the bolls of the native cotton do not open fully when they are ripe, the cotton suffers little damage from the undue exposure to the weather, which was often caused by the tardy visit of this official. Recently the growers have been encouraged by the Bokhara Government and the Russo-Bokhara Cotton Association to grow American cotton. The Government has exempted land planted with this type of cotton from certain taxes, while the Association has afforded assistance with cash loans and advances.

In Khiva, American cotton is grown which even rivals that of Ferghana, though native cotton is grown as well.

Efforts are being made to resuscitate the Turkestan cotton industry, and a certain amount of improvement has been achieved. The Chief Cotton Committee has endeavoured to inspire confidence by the supply of seed for planting purposes. Irrigation works are being proceeded with, and measures are being taken to protect the crop from damage by pests. It is considered that much progress would be effected by the more economical utilisation of the waters of the Sir Daria and the development of new irrigation works.

TRANS-CAUCASIA.—In Trans-Caucasia the cotton-growing areas are situated south of the Caspian Range, in the valleys through which various rivers flow, either westward to the Black Sea or eastward to the Caspian Sea, and also in the Valley of Erivan. The chief cotton-growing district is in the valley of the River Kura, which passes through Tiflis and falls into the Caspian near Baku. Next in importance is the province of Kutais on the River Rion, which falls into the Black Sea just north of Batum. Only about one-half of the cotton grown in this region is of American origin, and its admixture with the native Nanking cotton is a serious defect. Here also the lack of irrigation facilities is much felt.

According to an article recently published by the Russian Cotton Committee, the area under cotton in the Erivan province in 1924 amounted to 40,000 acres, from which the estimated yield was 12,780 500-lb. bales of lint.

COTTON PRODUCTION IN RUSSIA

(Bales of 500 lb., 000's omitted.)

Year.	Crop.	Year.	Crop.	Year.	Crop.
1904-5	540	1911-12	880	1918-19	330
1905-6	600	1912-13	870	1919-20	300
1906-7	760	1913-14	970	1920-21	120
1907-8	660	1914-15	1150	1921-22	80
1908-9	700	1915-16	1410	1922-23	140
1909-10	690	1916-17	1090	1923-24	150
1910-11	900	1917-18	610		

CHAPTER VIII

COTTON PRODUCTION IN THE BRITISH EMPIRE (I.) OTHER THAN INDIA

Lancashire's dependence on American cotton—The British Cotton Growing Association—The Empire Cotton Growing Corporation. Sudan: The Gezira Plain—Sudan Plantations Syndicate—Kassala—Tokar—Rain cotton areas—Various cotton areas—Grading cotton—Summary. Uganda: Transport difficulties—The cotton industry—Varieties of cotton—Seed distribution—Cotton cultivation—Marketing the crop—Ginneries—Uganda cotton production—Summary. Tanganyika: Cotton areas—Land tenure—The cotton industry. Nyasaland: The cotton industry—Cultivation—Pests and diseases—Ginning and baling. Kenya. South Africa: Cotton-growing areas—Climatic conditions—Soils—Land tenure—Agricultural conditions—Cotton-growing problems—Cotton yields—Insect pests and diseases—Handling and marketing the crop—Cotton grading—Production costs. Rhodesia: Southern Rhodesia—Land available—Increased interest in cotton—Northern Rhodesia.

HAVING discussed in some detail the conditions under which cotton is produced in the six largest cotton-producing countries of the world, we may now proceed to consider these conditions in other parts of the world, and firstly those in the British Empire other than India.

Lancashire's Dependence on American Cotton.—For many years Lancashire cotton spinners have been seriously perturbed by the circumstance that some 75 per cent of the raw cotton which they use is imported from one country, the United States, and that the supplies from this source are largely dependent on climatic and other vagaries. Of late years these supplies have been rendered still more precarious by the attacks of the boll weevil, higher production costs, and labour shortage. The result of all this has been to encourage the farmers to plant a greater diversity of crops, instead of concentrating so much on cotton. The average American crop was more than 6 per cent smaller in the last than in the previous decade. The ever-increasing demands of the American cotton mills also threatens to restrict the

quantity available for export. In 1900 there were less than 20 million cotton spindles in the country, but within twenty-one years they had increased to over 36 millions. During the same period America's consumption of raw cotton increased from 3,604,000 bales to 4,893,000 bales.

The best index of the relations of supply and demand is furnished by the price of "Middling American" cotton, which until 1909 had not reached 7d. per lb. since 1874.

During the cotton famine of the 'sixties, the price of American cotton in Liverpool rose as high as 31 $\frac{3}{4}$ d. per lb., but it fell in 1894 and 1898 to below 3d. per lb. The highest price reached by American cotton, as a result of the Great War of 1914, was 32.41d. per lb. in February 1920.

A short American crop causes prices to rise, threatens the Lancashire cotton-mill operatives with short time and privation, and much loss to the employers. The immense importance of the Lancashire cotton industry is well illustrated by the statement that in 1917 it was estimated that 10 millions of the population of this country were directly or indirectly dependent on the cotton trade for their daily bread, while in Lancashire alone a million people rely directly on the wages earned in the cotton trade.

The British Cotton Growing Association.—The unsatisfactory position as regards the supply of raw cotton for Lancashire led to the formation of the British Cotton Growing Association in 1902, primarily for the purpose of promoting the production of cotton in the British Empire. In 1904 it was granted a Royal Charter. The Association's work has been semi-philanthropic, and no interest has been paid on its subscribed capital of £500,000.

It has conducted investigations in every country in the Empire where there appeared to be a prospect of profitable cotton production. The Association's object has not been to grow cotton itself but to encourage others to do so. Most success has attended its efforts in the African possessions: Sudan, Uganda, Nigeria, and Nyasaland. A full account of the Association's activities is given by Sir William Himbury in the Foreword.

The Empire Cotton Growing Corporation.—As the result of a meeting of representatives of the British Cotton Growing Association and all the principal bodies connected with the

Lancashire cotton industry, which was held in 1916, a memorandum explaining the serious position of the Lancashire cotton industry was presented to H.M. Government. In this memorandum, among various recommendations pertinent to the subject, is included the following: "The B.C.G.A. has done the pioneer work. It has now reached the limit of its resources. Some new departure is now urgently required."

. . . "What is asked for is that the Government should appoint a Committee to consider the best method of continuing and developing the work inaugurated by the Association."

In July 1917 the Board of Trade appointed the Empire Cotton Growing Committee, "to investigate the best means of developing the growing of cotton within the Empire, and to advise the Government as to the necessary measures to be taken for this purpose". The outcome of the Committee's investigations and recommendations was the formation of the Empire Cotton Growing Corporation, which was incorporated by Royal Charter in 1921.

The Committee and the pioneers of this project fully appreciated that a public corporation of this kind should be engaged in fostering the cultivation of cotton within the Empire, and that private enterprise should be assisted. Moreover, that scientific and experimental work must be conducted at various centres under the Corporation's auspices, and the results tabulated at a central Bureau. Also that the functions of the Corporation should include: the creation of a staff of agricultural advisers and cotton experts to work with existing Agricultural Departments, the provision of facilities for training men for posts under these Departments, the establishment of a Bureau for the collection and dissemination of information on cotton matters, and the publication of a journal containing useful information appertaining to the production of cotton. As regards the marketing of crops, it was considered that such work should be conducted in conjunction with the B.C.G.A. The vitally important matter of improving the means of transporting the crop to market as likewise being one for the Corporation's attention, for this is too frequently the limiting factor in developing cotton growing, and especially is this the case in tropical Africa. In this connection it is to be observed that it is primarily in the matter of transport that the United States

competes on so much more favourable terms than British possessions.

The Corporation has an assured income, derived partly from a contribution of 1 million pounds made by the Government, and partly from the proceeds of a levy of sixpence per bale on all cotton purchased by spinners in this country. The proceeds from these two sources is expected to yield an annual sum of £150,000. In 1917 it was calculated that the approximate capital engaged in, or directly dependent upon, the cotton trade of this country was over £500,000,000; it is interesting to observe that the Corporation's annual income represents only .03 per cent of this sum. Notwithstanding the serious depression that has been experienced in the cotton trade since this calculation was made, its importance and value has appreciated. It is also noteworthy that the estimated capital required to grow the cotton that England purchases outside the Empire is approximately £250,000,000.

It is important to note that, excluding Indian cotton, the bulk of which is too short in staple to be of service to replace American cotton, the cotton produced in all parts of the Empire only increased from 2092 bales, of 400 lb. in weight, in 1902 to 261,900 bales in 1924. It will thus be seen that, unless much more rapid progress is made in the future, it will be many years before Lancashire is independent of the 4 million bales of American cotton which it annually consumes, at any rate as far as the British Empire is concerned.

The Corporation is directed by a Board of Trustees, and is analogous to an information and spending department without Treasury control. It has obtained special reports on the subject of cotton growing in Australia, Fiji, Nigeria, Nyasaland, South Africa, and Tanganyika, and has loaned expert assistance to these and several other countries.

In order that cotton growers may refer, for investigation at home, problems which they encounter and have not the facilities or time to elucidate themselves, it has granted subsidies to the Cambridge School of Agriculture, Imperial College of Science and Technology, Manchester University, and the Experimental Station at Rothamsted. The services of a specialist have been retained at each of these institutions for the purpose of dealing with such problems. It has further made a grant to the Imperial College of Tropical Agriculture,

Trinidad, and has established an experimental station at St. Vincent, West Indies. In the matter of research work, the Corporation also maintains close touch with the British Cotton Industry Research Association. A certain number of studentships have been granted to young men, usually to those possessing university degrees, so as to enable them to acquire additional training before proceeding to cotton-growing countries as agriculturists. Some of these students have been sent to the Trinidad College for this purpose; it therefore seems unfortunate that Trinidad is one of the few tropical countries in the Empire where cotton is not grown. The Corporation's quarterly journal, *The Empire Cotton Growing Review*, which made its appearance in January 1924, has proved a valuable addition to the all too scanty literature on this important subject.

The Corporation is taking steps to establish in Trinidad a central research station, for the purpose of investigating the cotton plant in all the phases of its growth. It is not proposed to provide strains of pure line seed for large-scale distribution. For it is considered that the utmost that can be done at this station, in this direction, is to breed out pure lines for special characteristics, which will require to be locally tested in different parts of the world to discover whether they are likely to be satisfactory in a particular country.

Further information regarding the activities of the British Cotton Growing Association and the Empire Cotton Growing Association in various parts of the Empire is given in the succeeding pages.

There is little doubt that the progress so far made in developing the cotton-growing industry in the Empire is to a very large extent commensurate with the progress shown in providing improved transport facilities. Certainly, so far as the African Colonies are concerned, every avenue of transport has been filled up as rapidly as transport arrangements have been made. Further development of the industry is likewise primarily dependent upon the provision of still more favourable transport.

SUDAN

The total area of Sudan is 1,014,600 square miles, or more than half the size of India. It extends from the southern

boundary of Egypt at 2° N. lat. to the northern shore of Albert Nyanza at $20^{\circ} 19'$ N. lat., and stretches from the French Sahara at $18^{\circ} 15'$ E. long., to Eritrea at $38^{\circ} 30'$ W. long. Its extreme limits are 1400 miles from north to south and 1200 miles from east to west. The population was at one time estimated at 10 millions, but the devastations of the Mahdi and the Kalifa reduced it to 2 millions; the existing settled administration has caused it to increase to nearly 6 millions.

North of Khartum the rainfall is only 3 inches, at Tokar it is 6.5 inches, at Kassala, which is 250 miles east of Khartum, it is 20 inches, south of Sennar on the Blue Nile it is also 20 inches, while in Bhar-el-Ghazal it is 40 inches. It is traversed by three great waterways, the White and the Blue Nile and the Atbara. Sudan embraces the whole of the upper valleys of the White Nile, excepting the equatorial lake region of Uganda; and the course of the Blue Nile from the Abyssinian frontier to its junction with the White Nile at Khartum is in Sudan Territory.

Pliny (A.D. 70) makes reference to cotton growing in the region now known as Sudan. Originally cotton was grown for domestic purposes only, and its production for commerce is of comparatively recent date. To-day, Sudan promises to supply a larger output of long-staple cotton than any other portion of the British Empire. It is anticipated that, at no distant date, its cotton crop will equal that of Egypt both in quantity and quality. In 1922 46 per cent of the crop consisted of Sakel, 44 per cent was Ashmouni, and 10 per cent Upland American. But where Upland has been acclimatised, it yields twice as heavily as Sakel.

The total cotton crop for 1924-25 is estimated at 35,600 bales of Sakel and 19,700 bales of American cotton.

Three methods of culture are practised, *i.e.* by the aid of water from pumps, flood water, and rainfall. During the period 1905 to 1918 the average annual area under cotton was as follows:

	Acres.
Under artificial irrigation	9,342
Under rain irrigation	6,228
Under natural flood irrigation	28,026
Total	<u>43,596</u>

Further particulars of the areas (acres) grown under each system, together with the exports of cotton from Sudan from 1911 to 1924, are given below :

Year.	1919.	1920.	1921.	1922.	1923.	1924.
Under artificial irrigation . . .	13,787	14,852	18,209	24,058	25,064	40,037
Under rain irrigation . . .	3,127	2,133	4,132	3,304	6,147	13,524
Under natural flood irrigation . .	41,294	44,284	62,184	56,911	30,377	58,105
Total . .	58,208	61,269	84,525	84,273	61,588	111,666

EXPORTS OF COTTON FROM SUDAN
(400-lb. Bales)

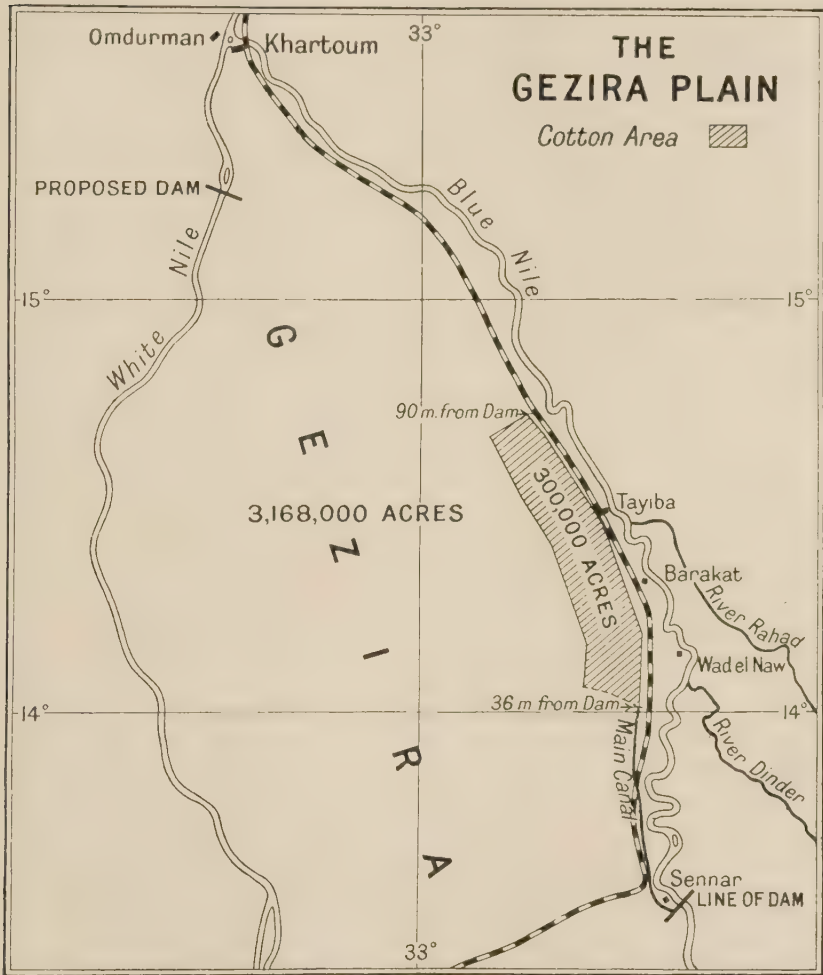
Year.	Bales.	Year.	Bales.	Year.	Bales.
1911	22,823	1916	16,219	1921	27,670
1912	15,000	1917	22,971	1922	24,240
1913	12,830	1918	11,263	1923	28,056
1914	9,435	1919	12,313	1924	46,074
1915	23,765	1920	21,780		

The Gezira Plain.—The principal cotton-growing project is the Gezira Plain, which is situated between the White and Blue Niles, where these rivers form a huge triangle of land, about 5 million acres in area, with the apex at Khartum and bounded on the south by the railway from Sennar to Kosti. The word Gezira means island, which the Arabs in olden times believed it to be. The land is flat but has a slight slope from the eastern boundary by the Blue Nile to the western limit on the White Nile, thus facilitating drainage and rendering irrigation channels practicable by utilising the Blue Nile stream.

The soil consists of the heavy black so-called cotton soil consisting of stiff loam with a considerable percentage of clay, and is 7 to 9 feet deep. It is believed that at one time a million acres were under grain cultivation.

The principal operations involved in the development of the scheme comprised the erection of an enormous dam, 2 miles (3600 yards) long, with a maximum height of 28·5

yards above the river bed, across the Blue Nile at Makwar, with a storage capacity of 500,000 million gallons contained in a lake fifty-two miles long formed above the dam, and the



Stanford's Geogr^l Estab^t London.

construction of a major canal system some 850 miles in length, 20 feet wide, and 6 to 7 feet deep; the water being distributed by means of subsidiary canals and field canals over a total length of 9000 miles.

The work was started in 1919, but owing to various difficulties, mainly of a financial nature, it was practically

suspended early in 1922. It was found possible to resume operations in the autumn of that year through the Imperial Government undertaking to guarantee an additional loan to enable the Sudan Government to meet the expenditure on these works. The total sum of the loans guaranteed by the British Government for these and subsidiary works amounts to £13,000,000.

Makwar was the site selected for the dam because it is the only place on this portion of the Blue Nile where there is a hard rocky foundation across the river bed.

The contractors were under an obligation to complete the dam in sufficient time for the irrigation of the 1925-26 crop. Good progress was made and sufficient water was available in July 1925 for the whole area it is proposed to irrigate. The dam was officially opened by the High Commissioner on January 21, 1926. There are 553,284 cubic yards of masonry in the dam of a total weight of one million tons. When the work of construction was at its height over 19,000 men were employed, and in order to beat the flood work had to be carried on continuously day and night, the night shifts being lighted by countless 2000 candle-power electric standards. For the present it has been decided to develop only 300,000 acres, of which one-third will be placed under cotton each year, one-third under leguminous crops, and one-third fallow. The Sudan Government has consented to restrict, for the present, the use of the water from the dam to this area, in view of Egypt's irrigation requirements. Moreover, the Egyptian Government would not consent to water being taken for the Gezira irrigation scheme between July 15 and March 1, *i.e.* when the Nile is low. There is, however, a prospect that these restrictions would be removed or modified if additional water were provided for Egypt by the construction of a proposed dam, or dams, on the White Nile. As regards the Blue Nile, more water could be conserved by erecting a dam or barrage near the Abyssinian border or on the outlet of Lake Tsana. A commission is now considering the whole question of the volume of water required by Egypt.

The Makwar Dam is designed to act mainly as a barrage and partly as a reservoir; for it raises the level of the river to such a height that from July 15 to January 18 the gravitation canal will irrigate the desired area by full flow,

or, in other words, from the normal flow of the river. From January 18 until July 18 the necessary supply of water for the cotton area will be obtained from that stored in the reservoir. It thus follows that during the period of low Nile the whole normal flow of the river is allowed to pass on to Egypt. Besides affecting the river upstream for 52 miles, the area that it will serve downstream will extend some 93 miles north of the dam and about 12 miles inland.

Before the completion of the Makwar Dam, cotton-growing operations had been carried out, on an area of about 20,000 feddans, by means of pumping stations established on the Blue Nile, first at Tayiba and later at Barakat, Hosh, and Wad el Naw. Cotton-growing experiments, which were commenced at Tayiba, to test the irrigable prospects of the Gezira Plain for cotton growing in the season July to March, amply demonstrated that Egyptian cotton could be successfully grown, and also that Sakel is the most profitable variety to grow. The quality of the cotton now produced is excellent and compares favourably with the best types grown in the Egyptian delta.

Sudan Plantations Syndicate.—The production of cotton is conducted on a co-partnership or profit-sharing basis between the Sudan Government, the native tenant-growers, and the Sudan Plantations Syndicate. The Government provides the land and water, and receives 35 per cent of the gross value of the crops produced. The native growers receive 40 per cent. The syndicate receives 25 per cent, but it provides the minor canal system, carries out the first ploughings, generally supervises the cultivation, provides ginning and storage facilities, and attends to the marketing of the crops. Some idea of the enormous extent of these operations may be gathered when it is stated that the minor canalisation embraces 11,000 miles of canals, and that the estimated sum that will be required annually for advances to tenants in a full working year amounts to £400,000.

The syndicate proposes to divide the 300,000 acres into nineteen separate, self-contained stations, each comprising about 15,790 acres.

Irrigation is governed by climatic conditions ; usually it is given every twelve to eighteen days, but heavier applications are necessary during the hot weather that prevails in

October than is generally the case in December and January when the weather is cooler.

The whole area is subdivided into plots of 10 acres (*hoarshas*), which is the regulation size for each tenant in the Gezira area. Tenants are responsible for constructing the necessary small waterways to flood their plots. Each *hoarsha* is divided by irrigation channels into 16 *angaias*; and each of these is irrigated separately. A three-course crop rotation is practised: cotton, legume, and fallow.

The land is ploughed by steam-driven implements and afterwards ridged by steam tackle; these operations are conducted by the syndicate, and the cost thereof is charged against each tenant and deducted at the end of the season from his share of the profits.

Sowing takes place between July 15 and the first few days of August, the seed being sown on the sides of the ridges. When the seedlings are about 2 inches high they are thinned out to two in a stand. Cotton picking begins at the end of December and continues to April or early May. After the harvest is over the plants are cut down and burnt. It will thus be seen that it is essentially a winter crop.

From the 20,000 feddans of cotton grown in the Gezira Plain under the syndicate's supervision in 1924, a crop of 17,679 400-lb. bales of lint were harvested, compared with 12,266 bales from a similar area in the previous year. In 1923 the highest average yield of 446 lb. of lint per feddan was obtained at Tayiba; Barakat and Hosh yielded 404 lb. and 346 lb. of lint per feddan respectively. The average yield throughout the Gezira in 1924 was just under 297 lb. of lint per feddan; the falling-off in the yield is mainly attributed to the attacks of the insect known as thrips, and to a bacterial disease called Black Arm. Both these pests, as well as aphids, have been troublesome for several years; further information about them is given in Chapters XV. and XVI.

In the rain cotton areas the pink boll-worm is a serious menace. All seed for planting is carefully sunned before issue, and this practice is reported to kill any worms in the seed.

Since the completion of the Makwar Dam in July 1925, 80,000 acres have been planted with cotton.

There has been a large increase in the population of the Gezira, chiefly due to the influx of Hausas and other tribes from Nigeria. These are a hard-working, law-abiding people, who work in perfect harmony with the older inhabitants. Incidentally, when these people return to Nigeria in the course of time, they should prove invaluable should the proposed cotton irrigation schemes develop in that country.

Transport is facilitated by the Sudan Government railways connecting with Port Sudan on the Red Sea, which traverse the whole of this region. The distance from Makwar to Khartum is about 150 miles, while that from Khartum to Port Sudan is 475 miles. The Makwar Dam is so constructed that it can take a line of railway across the top. This railway will be the loop connecting the Kassala-Gedaref and El Obeid lines, and in time will constitute a link in the main trade route from the Western Sudan to the Red Sea.

Kassala.—Another important cotton-growing scheme is in process of development near Kassala, in the delta of the Gash River. The Gash rises in the Abyssinian foothills; its flow is exceedingly variable, for it drains a long area of mountainous country, where a heavy but spasmodic rainfall obtains. The flood water arrives at Kassala early in July and continues for ten or eleven weeks. Just north of Kassala it starts to spill over the delta that it has laid down some fifty miles long, and is eventually lost in the desert sand. The delta is comprised of an alluvium of deep, rich black clay, where Sakel cotton is successfully grown; and yields as high as 200 to 250 lb. of lint per acre have been recorded. Cotton is planted as soon as the floods subside; the rains cease in October and no further irrigation is given. Little cultivation is done, but weeds grow prolifically and difficulty is experienced in keeping them in check.

Development work in the Gash Delta has been undertaken by the Kassala Cotton Company, which is closely allied to the Sudan Plantations Syndicate, on a profit-sharing system similar to that prevailing in the Gezira Plain. At present there are about 10,000 acres under cotton in this area. The total area of the delta comprises 500,000 acres, and it is anticipated that within ten years it will be possible to place 100,000 acres under irrigation.

The development of the scheme was originally retarded by the lack of transport, for the lint had to be carried by camels to Suakim, a distance of 250 miles. A railway, 217 miles in length, has now been built from Kassala to Thamiam, a station on the Port Sudan-Atbara line ; by this route Kassala is 337 miles distant from Port Sudan. This railway is the first link in a railway development scheme having for its object the opening up of the Eastern Sudan, which is to extend beyond Kassala to Gedaref, Mafaza, and Sennar. This extension is to be 260 miles long, and it will be taken over the Makwar Dam to connect with the existing main line, the Cape-to-Cairo route. This railway should tend to increase the area of rain-grown cotton in the fertile districts in the southern portion of the Kassala Province. It has already been shown that Upland cotton can be successfully grown in the Gedaref and Mafaza districts, where the rainfall is 25 inches.

Tokar.—Cotton was introduced to the Tokar district in the Red Sea Province about 1850–60 by Ahmed Mumtaz, a Turkish Pasha, who was Governor of Suakim. Its cultivation was interrupted by Dervish rule and little progress was made until the Sudan Government took the matter up in 1900. In this region a variable area of from 50,000 to 160,000 acres is annually flooded by the River Baraka, where Sakel cotton of excellent quality is also grown. Here again the rich alluvial soil retains sufficient moisture to grow cotton in any season that is not specially unfavourable. At present developments are largely dependent upon the volume of the Baraka flood, but, as at Kassala, an enormous water wastage could be obviated by artificial regulation of the flood.

The area under cotton is about 50,000 feddans. Tokar is only twenty miles distant from Trinkitat, on the Red Sea, and the cotton is conveyed there by a light railway.

Rain Cotton Areas.—The production of rain-grown American cotton in the Blue Nile Province has increased from forty bales in 1921–22 to 1100 bales in 1923–24. A certain amount of native cotton is also grown ; in 1923–24 this province produced 800 bales of this type. But the policy has been to encourage the cultivation of American cotton and the export of native cotton has been forbidden.

In the Kassala and Fung Provinces both American and

native cotton is grown, while in the White Nile Province native cotton is grown.

The trade in American cotton has encouraged efforts to pass off a mixture of American and native cotton for American cotton, but steps have been taken to prohibit this practice. The Cotton Ordinance of 1912 empowers regulations to be made to proclaim certain districts where only approved seed may be sown, and such regulations are being enforced to avoid the risk of variety mixture.

The progress made to date is the result of two years' steady propaganda and co-operation between the administrative and technical authorities. A market for the crop is found at Wad Medani, where the Sudan Plantations Syndicate has always been ready to pay a fair price for the crop; while the provincial staff and the agricultural inspector have taken over American cotton at any local centre and arranged for its transport to Wad Medani, where it has been sold on behalf of the grower. In order to secure uniformity in the quality of the staple, regulations have been framed to ensure that all cotton for export shall pass through certain recognised markets, where it will be properly graded by an official classifier.

In the Blue Nile Province the rainfall is only 14 inches, so that cotton can only be grown in depressions into which water drains, or in small areas so constructed near banks that water also concentrates; but possibilities of cultivating cotton are also offered on land flooded by the river. A greater rainfall obtains in the Fung and Kassala Provinces, but in the White Nile Province the conditions are similar to those prevailing in the Blue Nile Province, except that a greater area of river-flooded land is available for cotton cultivation.

It is considered that 200,000 acres could be grown under rain conditions in these four provinces, with an estimated yield of 20,000 to 40,000 bales in the immediate future, but there are prospects of still further development. It is largely owing to the increased production of rain-grown cotton that the total exports rose from 28,056 bales in 1923 to 46,074 bales in 1924.

Various Cotton Areas.—In the Berber and Dongola Provinces relatively small areas are served by pumping stations with water from the Nile. In the Kordofan and

Bhar-el-Ghazal Provinces, where the rainfall is usually sufficient for cotton cultivation, there are cotton plantations, partly of an experimental nature. The total productive capacity of all areas in Sudan under existing conditions is estimated as follows :

Type of Cultivation.	Locality.	Bales of 400 lb.	
		Sakel.	American.
Irrigation	Gezira scheme	60,000	..
"	Berber and Dongola pumping schemes	..	3,625
"	Zeidab S.P.S.	..	3,500
"	Kamlin and Shambat	450	..
"	Private pumps	500	2,000
"	Sakias, Berber, and Dongola.	..	2,100
Flood .	Tokar	10,000	..
" .	Kassala Cotton Co.	12,500	..
" .	Khor Arbaat	250	..
Rain .	Blue Nile Province	..	7,500
" .	Kassala Province, Gedaref district	..	2,750
" .	Kassala Province, Mefaza district	..	1,125
" .	Fung Province	..	5,750
" .	White Nile Province	..	3,000
" .	Upper Nile Province	..	2,000
" .	Nuba Mountains Province . .	..	625
" .	Bahr-el-Ghazal Province . .	..	375
" .	Mongalla Province	..	1,250
Total		83,700	35,600
		= 119,300	

Grading Cotton.—The whole of the cotton grown on the Gezira Plain is graded at the ginning factories of the Sudan Plantations Syndicate by their officials. These graders are usually Greeks or Egyptians who have been trained in Egypt by the chief exporting firms, but it is proposed to train Sudanese for this work.

All the cotton is graded before ginning, and one man is able to sample 800 bales of seed cotton in a day. These bales are packed by the tenant-farmer and weigh about 400 lb., the tare being 3 to 3½ lb. The cotton is roller-ginned and is baled in Shaw's hydraulic presses.

In the case of cotton plots that are situated comparatively near to the factory, the bales are transported by camel direct

to the factory, but from more distant plots they are transported by camel to one of the collecting stations and then consigned by railway to the factory. The tenant's name is marked on each bale, and on arrival at the factory it is weighed.

Summary.—Although the completion of the Makwar Dam enables 400,000 acres to be irrigated, of which 100,000 acres are to be cultivated with cotton each year, giving an estimated crop of 80,000 to 100,000 bales, this is only about one-tenth of the potential output, for the area available for cotton cultivation in the Gezira is estimated at from 3 to 4 million acres. In this connection it is interesting to note that the total area under cotton in Egypt is less than 2 million acres. An additional water supply is, however, necessary, but it is considered that this problem is not difficult of solution and at no excessive cost for capital works. In any case the existing dam is capable of holding up sufficient water to command a much larger area than 100,000 acres.

The Tokar and Gash Deltas are capable of considerable development; the former has an irrigable area up to 160,000 acres and the latter 200,000 acres, while greatly increased production is anticipated in the rain cotton areas.

It is therefore confidently expected that within fifteen years Sudan will produce a million bales of cotton.

UGANDA

Although systematic cotton cultivation in Uganda is a comparatively recent innovation, next to India it is the largest cotton-producing country in the British Empire. In 1904 only 54 bales of cotton were exported, but in 1924 the total exports of cotton had risen to 128,604 bales of 400 lb. each, which is as much as the total amount produced in the rest of the British Empire, excluding India. Production in the 1925 season is estimated at 200,000 bales. This development is all the more remarkable in that the natives are not naturally good farmers nor particularly hard workers, and it reflects the highest credit on the Administration and the Agricultural Department in particular.

The Uganda Protectorate comprises some 110,300 square miles and has a population of 3,000,000. It is situated in the

neighbourhood of and around the Lakes Victoria, Albert, and Albert Edward. Kampala, the principal commercial centre, is situated on the northern shore of Victoria Nyanza, while Entebbe, the administrative capital, is situated twenty-five miles farther west.

Transport Difficulties.—Further development of the cotton-growing industry is largely dependent on improved transport facilities. In some cases seed cotton is transported in bags of 60 lb. on the heads of natives, often for long distances, to the buying stations and ginneries, but this method of transport is decreasing yearly.

Owing to the numerous excellent laterite-gravel roads, and the large number of motor vehicles available, the transport of cotton to the railway system is most efficient. Heavy motor lorries are used on the metalled roads that serve the main arteries, while light motor lorries are used on the feeder roads. The most satisfactory form of lorry in use is the "Albion", with paraffin fuel. Fortunately there exists an efficient and well-organised Government motor transport service, which ensures that the rates charged by the commercial services are fair and reasonable.

Experiments with a system of road-rail transport, to replace motor lorries in districts not served by railways, have given satisfactory results on a line of about twenty miles in length, but this system is not likely to be extended to any outside district.

It is interesting to observe that the much-discussed Uganda Railway has not yet reached Uganda territory. It traverses Kenya for a distance of 776 miles. Starting from Kilindini, on the coast, it rises to a height of 8300 feet before reaching its terminus, Kisumu, on Lake Victoria, which is at a height of 3750 feet.

The Busoga Railway connects Jinja, on Lake Victoria, with Namasagali, on Lake Kioga, a distance of sixty-one miles.

The urgency of improved transport will be appreciated when it is stated that in some cases cotton is brought by motor lorry to the shores of Lake Kioga; from there it is transported by steamer to Namasagali, on the Busoga Railway, thence by railway to Jinja, where it is again shipped by steamer across Lake Victoria to Kisumu, and from Kisumu

by railway to Kilindini for shipment on the ocean-going steamer. By the time the cotton reaches the port it may have travelled upwards of a thousand miles.

In connection with the proposed railway development scheme, a branch line of 145 miles long takes off from the main line at Nakuru, in the Great Rift Valley, and climbs 3000 feet to the fertile Uasin Gishu plateau facing the south-eastern slopes of Mount Elgon.

It has been decided to continue the Uasin Gishu branch, skirting round the southern slopes of Mount Elgon into Uganda and connecting up with the Busoga Railway. When this is completed it is probable that the branch line from Nakuru to Uganda will be regarded as the main line, while the existing main line from Nakuru to Lake Victoria will become the subsidiary line. The new line will then give the Eastern Province, which produces most of the cotton, direct access to Kilindini, thus avoiding two transshipments, and it will, moreover, pass through thickly populated country where cotton production is increasing. It is in connection with the rehandling of the cotton at the lake ports that the chief difficulties are encountered. The total amount of lint and seed to be dealt with in the 1925-26 season at the different ports is estimated at 55,000 tons. Yet, notwithstanding these delays, cotton arrives at Kilindini faster than it can be exported. The cotton industry has developed too rapidly for the transport available, and consequently there has been congestion on the railway and at the ports, which has resulted in heavy damage to the cotton bales.

A branch from the Uganda extension is also projected, taking off probably from Tororo, just over the Uganda border, and proceeding in a northerly direction past the western slopes of Mount Elgon through Mbale to Kumi. This is a large cotton-growing area that stretches round the eastern shores of Lake Kioga.

Included in this railway development scheme is a branch southwards into Kavirondo, an area in Kenya, on the north-east shores of the lake, which is inhabited by an industrious tribe of natives, who have been encouraged by the Government to grow cotton. This railway will probably take off from the main Uganda branch some thirty miles before it reaches the Uganda border and proceed in the direction of Mumias.

As the cost of these schemes and some branch lines required in Kenya is beyond the present capacities of the local Governments, the Imperial Government has decided to grant a loan of £3,500,000 free of interest for five years. The total cost of these schemes is calculated at £8,000,000, and the balance is to be raised later by a public loan.

The completion of these railway works should set free for cotton growing a considerable number of natives, who are at present engaged as carriers or labourers on public works, for there are large areas of land suitable and available for more extensive cotton production. In 1895, when Uganda was declared a British Protectorate, some 6 million acres of land were made over to the Baganda, not communally to the tribe but mainly to the big chiefs personally. Latterly these chiefs have imposed higher rents on the peasantry and have bought up the lands of smaller men, which has been the cause of much discontent. In 1922 it was estimated that there were still 2740 square miles of Crown lands available.

The Cotton Industry.—Cotton is a rain-grown crop, and it is entirely produced by the natives on small plots of land, which do not generally exceed an acre in area. In the season 1923–24 the average area of the cotton plots in the Eastern Province was 1·34 acres and 0·57 acre in Buganda. The average yield of seed cotton per acre was 328 lb. and 512 lb. in the Eastern Province and Buganda respectively. That cotton is grown in such small isolated plots is undoubtedly an important factor in making the crop relatively free from serious pests and diseases. Certain native chiefs have, however, cotton plots that extend from 100 to 300 acres in area. In 1924 the total area under cotton cultivation was estimated at 572,814 acres, of which 298,000 acres were in the Eastern Province and 107,000 acres in Buganda.

Development in certain districts in the vicinity of the lake has been restricted by the prevalence of sleeping-sickness, but this obstacle will be overcome as the tsetse-fly, which carries the disease, becomes exterminated.

Cotton forms about 80 per cent of the total exports of the country. A tax of 6 cents ($\frac{3}{4}$ d.) per lb. is levied on all cotton lint exported, and the proceeds is mainly devoted to works likely to promote the development of the cotton industry.

The excise duty on cotton collected between January 1 and August 31, 1925, amounted to £165,802.

Varieties of Cotton.—The origin of the so-called indigenous cotton of Uganda is probably the Egyptian seed that was carried along the Nile Valley by Arab traders. The development of cotton growing was hindered by the unsettled state of the country until early in the twentieth century. In 1904 the Government and the Uganda Company imported seed of Egyptian, Brazilian, Sea Island, and American Upland varieties, and distributed it throughout the country. The Upland cotton proved best adapted to local conditions; it not only matured earlier but gave higher yields than the other varieties, so that Government decided to encourage its cultivation and to discard all the others.

Unfortunately the indiscriminate distribution of seed of all these varieties, and the consequent mixture and hybridisation that resulted, seriously affected the uniformity of the staple. Complaints as to the mixed character of the lint soon became rife, and stringent rules had to be enforced to prohibit the sowing of cotton seed other than that supplied by the Government. These rules likewise made it compulsory for the cotton plants to be destroyed as soon as the crop was picked. This procedure not only interdicts ratooned cotton, but checks the ravages of the cotton stainer and other insect pests that are a serious menace to the industry.

In 1908, 35 tons of the Black Rattler variety of Upland cotton were imported and distributed along with 21 tons of seed of the best Upland cotton seed available in Uganda. Much of the latter is considered to have originated from the variety Floradora that was introduced in 1904. In 1909 brokers reported this to be the finest cotton grown from Upland seed that had ever been imported into Liverpool from any country.

Later the long staple Upland varieties, Allen and Sunflower, were most in evidence, but the Egyptian type originally grown had not been totally eliminated.

To-day the cotton consists chiefly of a variety of Nyasaland Upland known as N 32, which was distributed in Serere, near Soroti, in 1921, and throughout Uganda in 1922. This variety has a robust habit, erect, with large erect basal branches and short sympodia. It bears large bolls and has

a high yield of as much as 590 lb. of seed cotton per acre. Its lint is fine, silky, strong and regular, averaging $1\frac{3}{16}$ inches long, with a ginning percentage of 31. Nevertheless, the cotton is by no means pure; there is an admixture of varieties, Sunflower being very prominent, and the effects of cross-fertilisation are apparent. Obviously this condition of affairs is conducive both to lack of lint uniformity and ultimate deterioration.

A new type of Nyasaland Upland cotton, No. 17, is being developed at the Serere experiment station, which produces good cotton of $1\frac{1}{4}$ to $1\frac{5}{16}$ inches staple and from 50 to 60 bolls per plant. This is being grown as a seed crop with a view to provide seed for cultivation on a segregated area of 2000 acres in the Kandunguru district for the supply of seed for a still more extended area.

Seed Distribution.—Government requisition cotton seed, free of cost, for planting purposes, but as far as circumstances permit a proportionate quantity is taken from each ginnery in a specified area. The sale of seed for planting is prohibited in view of the importance of ensuring that the crop is grown from seed approved by the Agricultural Department.

The problem of providing an adequate and continuous supply of pure seed is manifestly a difficult one in any country, and especially is this the case under the conditions prevailing in tropical Africa, but, taking into consideration its importance, every possible effort should be made to solve it. A constant supply of pure seed of the type of cotton which has been proved most profitable of cultivation should be raised under rigid supervision in the different areas for distribution in these areas, and the staff of the Agricultural Department ought to be sufficiently augmented to deal with the matter. The additional expenditure involved might well be met by charging a reasonable price for the seed, for much of that which is distributed free of charge at present is wasted, as the natives do not appreciate the value of what they obtain for nothing.

The ginning out-turn of Uganda cotton is 29 per cent of lint, while the staple is $1\frac{1}{8}$ to $1\frac{3}{16}$ inches in length. It compares favourably with staple American and Upper Egyptian cotton for counts ranging from 30's to 46's twist and 42's to 64's weft. There is little doubt that by careful selection a superior

type of cotton, with a uniform staple of $1\frac{3}{8}$ inches, and better suited to the different cotton-growing areas than that grown at present, could be evolved.

Cotton Cultivation.—The cotton plots are chiefly tilled with the primitive native hoe ; stumps are not extracted from the ground, so that ridge cultivation is impracticable. The clearing of new land is done by the men, but most of the subsequent cultivation and weeding is done by the women. The plants are widely spaced ; usually at the rate of one plant per square yard. The standard of cultivation is low.

In the Eastern Province planting begins in June, and in Buganda a month later. But as the land is largely used for growing food crops after the cotton is harvested, the planting of cotton is delayed if the food crops are late in maturing.

Picking begins in the Eastern Province in November, and in Buganda in the following month. No attempt is made to separate clean from stained cotton during picking operations ; any sorting that may be carried out is done in the native huts after picking.

Efforts are to be made to introduce stump extracting appliances and to improve the conditions of cotton cultivation by the introduction of ox-drawn ploughs. There are large numbers of cattle in the Eastern Province, where it is considered that this method of cultivation could be generally adopted with great advantage. In Busoga and Buganda, where heavy bush obtains and cattle are scarce, there is little prospect at present for similar progress. The Empire Cotton Growing Corporation has provided 300 ploughs, and has also supplied the Government with the services of four agriculturists to strengthen the Agricultural Department.

The opinion is confidently expressed that more intensive cultivation is preferable to a policy of opening up more distant areas. In other words, efforts should be directed to producing more cotton of better and more uniform quality by scientific research and the adoption of improved agricultural methods. In the latter connection it should be observed that Uganda is virtually a one-crop country, so that the introduction of disease-resisting and productive crop rotations is of prime importance, and more especially those affecting the local food supply.

Marketing the Crop.—The purchase of the crop is keenly

competed for by a number of European and Indian firms, so that usually an adequate price to the grower is assured.

It is significant that the Japanese demand for Uganda cotton has steadily increased, and Japanese firms, working in conjunction with several Indian firms, have paid higher prices than Liverpool shippers could touch with safety. In 1924 Japanese firms exported 50,000 bales of Uganda cotton, and there is every indication that this trade is on the increase, although English mills have complained of the lack of supplies. It is also interesting to observe that considerable quantities of Uganda cotton also go to India.

The Government's policy is to permit free competition for the purchase of the seed cotton, but necessary safeguards are imposed to ensure due protection of the cotton from deterioration after purchase. There is no restriction on the activities of middlemen, nor does Government interfere in the matter of price regulation.

In so far as circumstances permit, a "five-mile radius" between ginneries and central markets is accepted as a guiding principle. In the Eastern Province cotton is bought either at the ginneries or at central markets; at the latter a large number of small stores are maintained, where cotton is purchased on behalf of ginneries or middlemen. The conditions are different in Buganda, where cotton is bought at the ginneries and at numerous widely distributed buying posts; but it is proposed to establish the same system of purchase as prevails in the Eastern Province.

It would appear that the system of central markets and buying by middlemen could be advantageously dispensed with, for it is difficult to trace the origin of seed for planting purposes. It entails unnecessary expense for stores, wages, and middlemen's profits; moreover supervision is much more readily maintained at the ginneries, seed for planting purposes can be more efficiently controlled, better storage facilities exist, and the ginners are obviously far more interested in the reputation of the country's cotton than the middlemen and the native buyers in the markets, and will thus devote greater attention to cotton grading. Another important factor in favour of ginnery purchase is that the growers are much less likely to be cheated at the ginnery than at scattered buying posts.

Although Government recognise the desirability of cotton grading, they have not yet seen the way clear to enforce a practicable grading system by legislation, but maintain that economic factors should induce the grower to grade his crop in self-interest. It seems doubtful, however, whether the average native grower will take the trouble to grade his cotton so long as he can find a ready and profitable sale for the ungraded commodity.

So profitable has cotton cultivation proved under existing conditions that many of the Buganda natives are employing natives of the more primitive tribes to cultivate their plots. The industry is developing at a rate beyond all expectations ; indeed there appears to be a possibility that progress is too rapid, for the disturbance of local economic conditions is already in evidence by the serious labour shortage on the railway and at the ginneries. This condition of affairs has been largely brought about by the prosperity resulting from the cotton-growing industry. The natives find that the cultivation of a small area of cotton supplies all their requirements, and the question as to the most satisfactory method of providing labour for essential services is one that demands most careful attention and consideration.

A Cotton Control Board has been formed, whose functions will include the selection of central markets and the consideration of applications for ginnery erection. The Board will act in an advisory capacity to the Government in all matters affecting the cotton industry.

Ginneries.—In the 1924–25 season there were 147 power ginneries and 3 press-houses, and more ginneries were being erected in every province. The Cotton Control Board has recommended that the number of ginneries should not be increased for the present unless it is proved that they are necessary in new areas.

Ginning and baling are conducted by both European and Indian firms. As regards the former, their ginneries are for the most part well built and the machinery is generally in good running order. Both roller and saw gins are employed, but the lint from each type of gin is kept and baled separately. Seed cotton openers are used in connection with the roller gins, but these gins are hand-fed, as the automatic feeders are not popular, although under proper supervision they do their work

well and are economical of labour. In some of the ginneries the seed cotton is hand-picked before ginning and the lint is hand-picked before baling, and a remarkably pure, clean lint is then produced.

Generally the Indian ginneries do not compare favourably with the European ginneries, for although their construction is similar the standard of workmanship is inferior. Roller gins are mostly used and seed-cotton cleaners are installed, but hand-picking is not usually practised.

Much difference of opinion prevails as to whether the use of the roller or saw gin is preferable. Properly maintained, both types of gin appear to give satisfactory results with Uganda cotton; but to give the best results the roller gin requires frequent attention, while once the saw gin is properly set it will function satisfactorily for a much longer period without attention. The saw gin cleans the cotton more thoroughly and thus produces lint of more uniform appearance, and its output is about four times greater than that of the roller gin. On the other hand, when the seed cotton is carefully hand-picked the roller gin turns out a better spinning cotton, for it handles the lint more gently.

Motive power is provided by producer gas, steam, and oil engines. Linter gins are not in use. Ginneries and stores are built of corrugated iron, the former having two stories; the latter are built on a brick foundation extending about 3 feet above the ground to make them rat-proof, and they have concrete floors. Platt's gins and seed-cotton cleaners and Shaw's hydraulic presses are employed almost universally.

UGANDA COTTON PRODUCTION

(In Bales of 400 lb.)

Year.	Crop.	Year.	Crop.	Year.	Crop.
1909	5,700	1915	25,800	1921	81,200
1910	12,900	1916	23,500	1922	40,000
1911	20,400	1917	25,300	1923	94,000
1912	27,700	1918	26,800	1924	128,600
1913	27,000	1919	36,500	1925 *	200,000
1914	37,000	1920	51,800		

* Estimated.

The reduced yield of 1922 was largely caused by a deficient rainfall and is significant of what may occur again.

It is estimated that the area under cotton for the 1924-25 season is approximately half a million acres, which shows an increase of about 40 per cent on the previous season. As favourable climatic conditions have prevailed, the new crop is estimated at 200,000 bales.

Summary.—The Uganda cotton-growing industry has attained a definite and assured position among the cotton-producing countries of the world; the production now amounts to approximately 200,000 bales, which will probably increase to half a million bales in a few years.

Under the conditions which obtain at present, it is preferable to attempt to produce more cotton of better and more uniform quality on the existing cultivated area by more intensive cultivation and crop improvement, rather than extend the cotton-growing area, which would be conducive to the increase of existing labour shortage and transport difficulties.

An increased agricultural staff is essential, not only to permit of better supervision and control of the growing and marketing of the crop, but to raise and maintain an adequate supply of pure seed of high quality to replace the existing variety mixture.

Interior transport is satisfactory owing to the excellent roads and motor transport services, but in order to expedite the movement of the crop the completion of the proposed railway extensions is urgently needed so as to avoid the repeated rehandling at the lake ports, while better facilities for more expeditious shipment at Kilindini are also most desirable.

TANGANYIKA

The mandated territory of Tanganyika, formerly German East Africa, is bounded on the east by the Indian Ocean, for a distance of 500 miles, from the Uмба River in the north to the Rovuma River in the south. The northern boundary runs approximately north-west from the mouth of the Rovuma River to the intersection of the first parallel of southern latitude with the eastern shore of Victoria Nyanza, making a curve round the foot of Mount Kilimanjaro, which is in Tanganyika

territory. It is bounded on the north by Kenya and Uganda, on the west by the Belgian Congo, on the south-west by Rhodesia and Nyasaland, and on the south by Portuguese East Africa. The territory has an area of 350,000 square miles. The population comprises 4 million natives, 2200 Europeans, and 17,500 Indians, Arabs, Somalis, and Goans. The soil and climate are in many parts well adapted to cotton production. Unfortunately the rainfall varies considerably from year to year, and even in the same year in adjacent districts. The rainfall is low for a tropical country. The annual average rainfall varies from 27 inches at Masasi and Shirati to 70·4 inches at Mahenge. In one year certain districts may suffer from drought and crop failure, while others suffer severely through excessive rain.

Cotton Areas.—The areas considered most suitable for cotton growing are: (1) The coastal belt, chiefly Lindi, Rufiji, and Bagamoyo; (2) the Morogoro and Kilossa region; and (3) Mwanza and Tabora, in the Lake Victoria basin. There are also prospects of cotton being produced in fair quantities in the vicinity of the Tanga Railway.

Along the coastal belt the land rises from sea-level to a height of 600 feet. It contains extensive flats that are easily cleared, where the soil is rich and there is an adequate rainfall for cotton production. The soil of the Rufiji Valley is exceptionally fertile. The average annual rainfall at various places along the coast is: Lindi, 34 inches; Dar-es-Salaam, 43·3 inches; Bagamoyo, 43 inches; and Tanga, 61 inches. The recognised harbours are: Lindi, Kilwa-Kisiwana, the mouth of the Rufiji River, Dar-es-Salaam, Bagamoyo, Pangani, and Tanga; but there are numerous creeks and inlets that afford safe harbourage for dhows. Except on the coast this belt is sparsely populated.

The Rufiji is navigable by light steamers for eighty miles from its mouth, and during a part of the year canoes may be used beyond this limit. Generally transport is not difficult owing to the existence of various rivers, inlets, and harbours. A light railway extends for eighty-five miles from Lindi to Masasi.

The Morogoro and Kilossa region is situated west of Dar-es-Salaam and extends for ninety miles along the Central Railway, which runs from Dar-es-Salaam through Tabora to

Lake Tanganyika. The country is of an undulating character, and the altitude ranges from 1000 to 3000 feet. The soil is fertile. The average annual rainfall of Kilossa and Morogoro is 33 inches and 44·4 inches respectively. There is a good supply of water that could probably be utilised for irrigation purposes. There is a fair supply of labour, but animals cannot be used to any great extent for transport and agricultural operations owing to the prevalence of tsetse-fly.

The lake basin comprises the Nyanza districts and the island of Ukerewe ; it lies at an elevation of 4000 feet above sea-level. The land is flat and is easily cleared, and in many parts the soil is rich. Little tsetse-fly is found in this region. Transport is facilitated by the proximity of the lake ; cotton is transported by steamer to Kisumu and thence to the coast by the Uganda Railway.

Cotton grown in the Tanga Railway area has given promising results, so that if the industry develops in this region excellent transport is provided by the railway, which connects the port of Tanga with Moshi, a distance of 219 miles. In this part of the country is also the Voi-Kahe Railway, which runs in an easterly direction from Kahe on the Tanga Railway to Voi on the Uganda Railway, a distance of ninety-three miles.

Land Tenure.—The position as regards land tenure is rather complicated, for it involves three distinct systems that are antagonistic though existing side by side. Briefly stated they comprise : (1) The ancient tribal system based upon a communal ownership, which is most commonly met with over a great part of Africa, and is the one that is most prevalent in this territory ; (2) the purely private and individualistic Arab system, by which the original alien immigrant took possession of a desirable area of land without consideration for the possible rights of the State or the community ; (3) the European system, whereby Government grants of property are made to certain individuals or companies after, at any rate nominal, consideration of the rights of the native community and the development of the country. The introduction and operation of this system by the Germans caused considerable native unrest, for under it large grants of land were often made with little or no consideration for the rights or requirements of the native population.

The Germans proclaimed all unowned land to be Crown land, subject to the rights of private persons or of chiefs or native communities ; such Crown lands could be granted by the governor either by way of transfer of ownership or by lease. The transfer of land by natives to non-natives was subject to the sanction of the governor. The Germans introduced their system of registration of title in a *Grundbüch*, which assured an indefeasible title. In certain districts land registers were established and were available for non-natives.

It is proposed to substitute the Torrens system for the German *Grundbücher* and land registers. All land is regarded as belonging to the native, and cannot be alienated except by the act of Government. For the present, no land can be acquired by Europeans other than the formerly German-owned plantations. Many of these estates are freehold and include much land that is well suited for cotton cultivation. In Morogoro a number of Greeks and Indians are growing cotton on estates of varying size that they purchased from the custodian of enemy properties.

The Cotton Industry.—When the Germans occupied the country in 1885 they found the natives growing cotton for domestic purposes ; Indian cotton, *G. herbaceum*, being grown on the coast, and Peruvian cotton, *G. peruvianum*, in the region of the great lakes. They commenced their efforts to establish cotton plantations in the late 'eighties, but with little practical result until the work was taken up by the Kolonial-wirtschaftliche Komitee, which corresponds to a certain extent to the B.C.G.A. Samples of Egyptian cotton that were produced on the coast were favourably reported on in Hamburg. The German Government adopted the policy of "encouraging" the natives to grow cotton ! One of the contributory causes of a serious native rebellion that broke out in 1905 was the system of compulsory labour enforced for European-owned plantations.

A good deal of controversy took place as to the varieties best adapted for cultivation. Numerous kinds were experimented with at the Government experiment stations. The general opinion arrived at appears to have been in favour of Egyptian cotton in districts below 1900 feet elevation above sea-level, and Upland at higher elevations. The natives,

however, exhibited a tendency to abandon Egyptian cotton for Upland, because the latter was better able to withstand insect pests and unfavourable weather conditions, and was more prolific. Moreover, Upland cotton appeared to be less affected by a peculiar leaf-curl disease similar to that which proved so destructive to native cotton in Nigeria. In fact, the natives were disinclined to grow cotton, and were suspicious whenever a fall in price took place.

For several years the Komitee guaranteed a minimum buying price. Seed for planting was distributed free of charge, instructors in cotton growing were employed, and text-books in the vernacular, on the subject of cotton growing, were published for distribution among the farmers. Prizes were also offered as a stimulus to increased production. The Government devoted a good deal of attention to ensure the supply of pure seed and to the maintenance of the quality of the cotton. Non-officials were not permitted to issue seed to the natives for planting. Europeans could procure seed at moderate rates from the Government stations, and were enabled to purchase machinery at manufacturers' prices. Freights were regulated and space was secured for the cotton crop. Four cotton experiment stations and seed farms were established at Mpanganya in the Rufiji Valley, Myombo in the Kilossa district, Makiwa in the Lindi district, and Kibongoto in the Moshi district. Owing to the prevalence of the pink boll-worm and other insect pests, an ordinance was enacted in 1910 to enforce the destruction by burning of the cotton plants by a fixed date after the cotton harvest.

The chief districts where cotton was grown were : Kilossa, Rufiji Valley, Mwanza, and Lindi. In 1911 there were seventeen steam ploughs in operation, fourteen power gins, and forty-nine small gins. In 1913 there were 32,000 acres of cotton in various European-owned plantations, as well as 47,000 acres in native farms. The crop for 1913-14 was estimated at 12,000 bales.

The Empire Cotton Growing Corporation (E.C.G.C.) has lent the services of a cotton specialist to the new Administration, who has been conducting cotton selection work and varietal tests at Mpanganya and Morogoro, and it is hoped to develop varieties specially adapted to these two areas. The E.C.G.C. also contributed a sum of £5000 to the budget

of the Agricultural Department for the year 1923-24 in order that the staff might be increased and more cotton work taken in hand. At first the development of cotton growing under the new Administration was not very gratifying. The quantity of seed distributed for the season 1922-23 exceeded by 65 per cent that of the preceding season, yet the crop was smaller than the previous one. The total crop for 1921-22 and 1922-23 was 7400 400-lb. bales and 7200 bales respectively; 11,400 bales were produced in 1923-24, while the crop for 1924-25 is estimated at 17,500 bales. The greater part (about 70 per cent) of this has been produced by native cultivators on their own farms. The efforts of the Government have been mainly devoted to extending and improving this method of production, for it is considered doubtful whether the production of cotton on large European-owned estates will ever develop to any great extent.

The standard of the native's cultivation is low. A system of shifting cultivation prevails. After the land has been cleared of scrub and burned, it is lightly dug over with the hoe, and when the rains begin four or five seeds are dropped into holes dug at random. The cotton plants receive little attention beyond keeping them clear of weeds. With the view to secure a fair price to the grower for his crop, auctions have been instituted under Government control. Government also maintains control of the seed supply. The general introduction of the ox-plough to districts free from tsetse-fly, in substitution of the primitive hoe in general use, would probably tend to improve the output of cotton. In some districts the natives have taken up ploughing very readily. The only competing crops of any importance are sesamum and groundnut, and both of these could be grown to advantage in rotation with cotton.

The native's wants are few, being practically limited to providing sufficient food for the use of his family, and it is necessary to persuade him of the advantages attaching to the production of a cash crop such as cotton. His surplus food crops he exchanges with the Indian or Arab traders for his few domestic requirements. His chief incentives to grow cotton are the payment of his hut or poll tax, and the personal influence of the District Administrative Officer.

The problem of improved transport is likewise an im-

portant factor in the development of the industry. A project is under consideration for the construction of a railway from Tabora, on the Central Railway, to Mwanza, on Lake Victoria. Expenditure has been sanctioned for the construction of the first eighty miles from Tabora to Kahama, as well as for the reconditioning of part of the Lindi Light Railway and its extension to Lindi Harbour. Improved roads and enterprise in mechanical transport are much needed.

The cotton is now mainly grown from Upland seed imported from Uganda, but it consists of a variety of types, including Egyptian. Samples of the 1921-22 crop from the Morogoro and Mwanza districts have been examined at the Imperial Institute. Their chief defects were found to be in the irregularity in the length and strength of the fibre, and the presence of stained and immature fibre. The ginning out-turn is about 29 per cent of lint. Samples of Mwanza cotton that were recently examined had a staple of $1\frac{1}{8}$ inch, and were remarkably free from leaf and with no trace of stain, and of medium strength. It should therefore be possible to improve the crop to a considerable extent by the use of purer seed, better cultural methods, and the discovery of varieties best adapted for growing in particular districts.

The production of cotton by natives in the seasons 1922-23 and 1923-24 is shown in the following table :

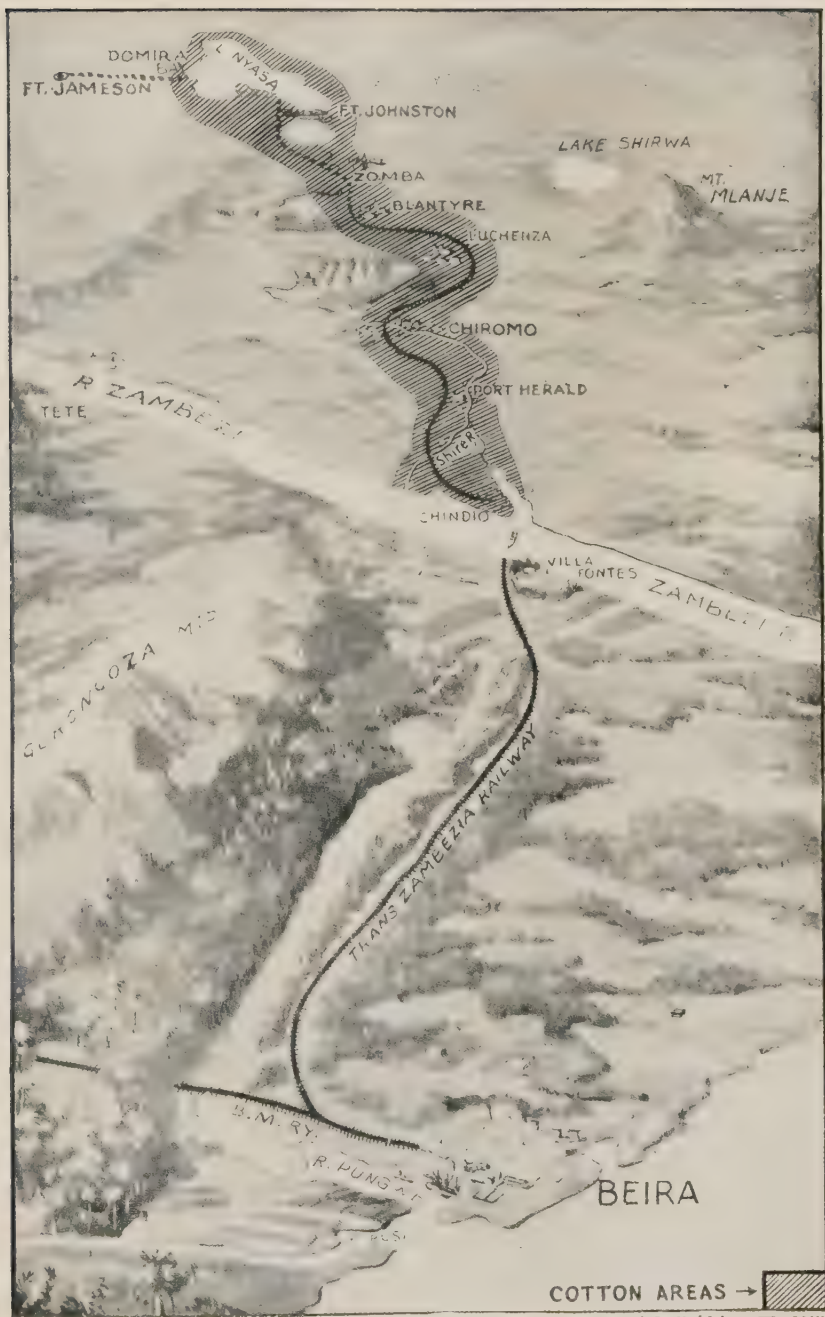
District.	Lint in lb.	
	1922-23.	1923-24.
Morogoro	98,666	448,965
Mwanza (including Shinyanga)	714,366	1,753,117
Rufiji	245,042	238,579
Lindi	54,432	248,469
Bagamoyo	56,858	50,319
Kilwa	39,796	124,905
Moshi	7,421	33,891
Dar-es-Salaam	379	29,601
Pangani	4,950	1,639
Mahenge	6,681	7,725
Tanga and Usambara	508	3,500
Total	1,229,099	2,940,710
Percentage of total production of the country	42·8	64·3

During the 1923-24 season there were nineteen ginneries in operation, and it is anticipated that fourteen additional will shortly be established. In the same season 1047 tons of seed were issued to native planters and 500 tons to non-native planters. The seed planted by the natives is entirely under Government control, and is selected in connection with the process of grading the cotton at the Government markets.

NYASALAND

Nyasaland consists of a long strip of country in Central Africa running north and south; it is about 520 miles in length and varies in width from 20 to 100 miles, with a superficies of 40,000 square miles and a population of 1,500,000. The most southerly point is 130 miles from the sea. It has for its boundaries: Portuguese East Africa on the south and east, Rhodesia on the west, and Tanganyika on the north and north-east. On the east and west are high mountain ranges. The Shiré highlands are situated in the centre below the lake area. The Shiré River traverses the western slopes of the Shiré highlands, and west of this is the low country. The latter is only about 200 feet above sea-level, and includes the Port Herald, Chiromo, and Chikwawa districts. Some forty miles farther up the river the country rises to 900 feet, and continues to rise gradually to 1500 feet at the lake shore. Eastwards it rises to the plateau comprising the Zomba and Malanje districts, with an elevation of 2500 feet.

The railway runs for a distance of 114 miles from Chindio, on the Zambesi, through Port Herald and Chiromo, and then ascends the Shiré highlands to Blantyre, which is at an elevation of 4000 feet. It has been decided to construct a bridge over the Zambesi on the Trans-Zambesi Railway; when this is completed the transport of cotton will be greatly facilitated. It has been proposed to connect the lake region with the Zambesi by railway; if this takes place it is anticipated that more extensive cotton planting will be carried out in the lake areas, which is impracticable at present owing to the heavy cost of transport. The question of clearing the Shiré River for traffic is also under consideration.



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TRANS-ZAMBEZIA AND SHIRE HIGHLANDS RAILWAY

The Cotton Industry.—Early in 1860 Livingstone invited attention to the importance of Nyasaland as a cotton-producing country. At this period an introduced cotton, known locally as tonje-manga, was grown as a perennial crop in small plots by nearly every family in the country. To-day systematic cotton cultivation is restricted to those portions of the country that are within easy reach of the railway or have access to river transport.

As regards soil, climate, and population, practically the whole country below a level of 3000 feet is suited to the cultivation of cotton, but it is probable that cultivation will be most extended at elevations of from 1000 to 2000 feet. But in many areas the lack of transport facilities are a serious deterrent. Even where these facilities exist the high rates that prevail are a severe handicap to cotton production. The cost of cotton transport from railhead to Europe is estimated at 1d. per lb. of lint, and about one-half of this amount is absorbed by railway charges from railhead to Chindio. Inclusive of ginning and baling charges, it costs 3½d. per lb. to get the cotton to Europe. Hitherto the cotton had to be conveyed down the Zambesi to Chinde, where it was transhipped in barges for Beira and there loaded on ocean-going steamers for Liverpool. The recently opened Zambesi-Beira Railway should do much to improve the marketing of Nyasaland cotton.

The industry differs from that of other British possessions in tropical Africa, for until quite recently 80 per cent of the crop was grown on European-owned plantations, by means of hired native labour. Recently labour shortage has been experienced, and wages are twice as high as they were before 1914. The total crop for 1924 amounted to 5548 (400 lb.) bales, of which 2040 bales were native-grown cotton, and it is estimated that the native crop during the 1925 season amounted to 4700 bales.

The best results have been obtained in the Port Herald, Balakas, and Fort Johnston districts, but the yield per acre is rather low and there is still room for improvement in the quality of the cotton. The total acreage planted and the yield of lint per acre at various periods are shown overleaf.

Year.	Total Cotton Acreage.	Yield of Lint per Acre.
		lb.
1910	8,975	194
1916	27,342	123
1919	12,658	73
1922	26,545	84
1923	20,948	104
1924	26,120	85

The export of cotton from Nyasaland began about 1902. Shortly afterwards seed of Egyptian, Sea Island, Brazilian, and American cottons were imported through various agencies, with the chaotic results as regards seed mixture and discouragement that are usually associated with action of this nature. Later, efforts were made to confine the Egyptian cotton to the warmer districts of the lower river and American long staple cotton to the uplands. More recently the tendency has been for the latter type also to be grown in the lowlands. Generally, however, the crop comprises a mixture of different forms.

Cultivation.—The methods of cotton cultivation adopted by Europeans and natives are very similar. The European is more careful to sow at the proper season, and he generally devotes more care to the crop, and, besides, applies more method to his work. In clearing new land for cotton, all but the largest trees are cut down to within 3 feet of the ground, and as much as possible of the timber is burnt. In some cases all the land is dug up with the native hoe. In others only parallel strips, about 4 feet apart, are dug up, and these form the lines on which the cotton is sown. In both cases ridges are made about 4 feet apart, just before the rainy season commences.

At the higher elevations sowing is done in November and December, but it is done later as the elevation gets less ; in the low country it is carried out as late as March. The seed is sown by hand on the ridge at intervals of from 1 to 2½ feet. The quantity sown is unnecessarily large, and as many as twenty or thirty seedlings may be seen at one stand. The wide distance is adopted when the season is early and on the more open soils, because these conditions are more conducive to a larger plant growth. The plants are thinned

out when they are about 9 inches high, two being left at each stand.

Weeding is carried out as it is considered necessary, and at the same time the ridges are made up by scraping the soil from between the rows of plants on to the ridge. At the final weeding the ridges often attain a height of 18 inches.

Preparation of the land for the succeeding crop takes the form of merely remaking the old ridges. The more careful growers, however, dig up the ground between the rows, and split the old ridges to form new ones on the newly-dug ground. This procedure continues until cotton growing is no longer profitable; the old site is then abandoned and a new one is cleared. Where the absence of tsetse-fly renders the use of cattle practicable, they are employed for ploughing, and to a less extent for interculture as well. But the use of cattle for tillage operations could be much more generally adopted with advantage. A proper system of crop rotation is not practised. Fertilisers are not applied to the land, even where cattle are kept; and where ginning is carried out on the farm, the only use made of the cotton seed is as fuel for the engines.

In the course of cotton picking some growers practise a system of grading in the field—each picker being made to pick the clean cotton into one receptacle and the damaged cotton into another. Other growers prefer to grade the cotton after it is picked. Generally the cotton is carefully graded into three qualities. Grade 1 consists of clean, undamaged cotton; Grade 2 is stained, attacked by boll-worm and late pickings; while Grade 3 is mainly composed of immature cotton. The staple of the cotton is by no means uniform, for it varies in length from $\frac{3}{4}$ to $1\frac{1}{2}$ inches. The lint in some cases is silky and in others quite coarse and harsh. The ginning percentage of lint of a number of samples examined varied from 26 to 35.

Pests and Diseases.—The most serious disease of cotton is boll-rot, caused by a fungus or bacterium. Diseased bolls fail to open fully, and when the crop is picked the lower half of the lock remains in the boll; in the case of a severe attack, the whole of the lint is stained yellow and the seed is destroyed. The common black mould, *Aspergillus niger*, is also stated

to cause damage, when it follows boll-worm attack, by weakening the fibre and discolouring it.

Three boll-worms cause a considerable amount of damage; these are the Sudan boll-worm, *Diparopsis castanea*, Egyptian boll-worm, *Earias insulana*, and the American boll-worm, *Chloridea obsoleta*. Of these the Sudan boll-worm is most troublesome. A certain amount of damage is also caused by leaf-hoppers, aphids, stainers, and red spider.

Ginning and Baling.—Ginning is chiefly done by single-roller gins, though in a few places the saw gin is in use; it is considered that double-roller gins could be substituted with advantage. A large number of small presses are in use, which put up the cotton in half-pressed bales of 100 to 120 lb. in weight; these are a convenient size and weight for two carriers to transport to the large presses. Several large hydraulic presses are in operation in the country, and these turn out bales for export with a density of 28 cubic feet per 400-lb. bale. Ginning and baling charges amount to about £11 per ton.

Although the European planter at present produces more than 60 per cent of the crop, it seems probable that the native will produce a much greater proportion of the crop as the country becomes more opened up. The areas where cotton is likely to be most successful are situated in the less temperate and more unhealthy regions, which are unsuited for the permanent residence of Europeans. Again, the native has a far larger area of land at his disposal than the European, and he is thus able to change the site of his farm more frequently. Government has done much to encourage native cultivation, and has always supplied the native grower with seed free of charge for planting purposes, but this has never been done for the planter.

With a view to encourage more extensive cotton cultivation by the natives, the Government has entered into a contract with the B.C.G.A. with regard to the purchase of the crop for a period of five years; under this agreement the B.C.G.A. will purchase all cotton grown by natives on Crown lands at a guaranteed price. This arrangement has been greatly appreciated by the natives, and has caused increased interest to be taken in the industry.

The E.C.G.C. has appointed a cotton specialist, with a

small staff, to assist the Agricultural Department in developing the industry. A cotton experiment station has been established and placed in charge of officers appointed by the E.C.G.C. The corporation has also provided the services of an entomologist for the purpose of studying cotton pests.

COTTON PRODUCTION IN NYASALAND
(In Bales of 400 lb.)

Year.	Crop.	Year.	Crop.	Year.	Crop.
1902	2	1910	3700	1918	6700
1903	142	1911	4200	1919	2300
1904	713	1912	7500	1920	2300
1905	1942	1913	6400	1921	3700
1906	1757	1914	6600	1922	5600
1907	1655	1915	7700	1923	5500
1908	1845	1916	8700	1924	5600
1909	2300	1917	2200	1925	9500

Summary.—The bulk of the Nyasaland cotton crop is still produced on plantations owned by Europeans, with hired native labour working under white supervision ; nevertheless, future development mainly depends upon the native cotton-growing industry. The Cotton Buying Agreement has caused renewed interest to be taken by the natives in cotton growing, and it is anticipated that the industry will be firmly established under the system of guaranteed prices. Much larger areas are being cleared for cotton growing ; native cotton production in 1925 is estimated to be more than double that of the previous year.

Given the proposed improved transport facilities, an adequate supply of pure seed of superior quality, and the adoption of more intensive cultural methods to increase the yield per acre, still more extensive developments should soon be manifest.

KENYA

The area of Kenya is 240,000 square miles ; it joins Uganda on the west and Tanganyika on the south. The population is estimated at four millions.

During the last twenty years spasmodic efforts have been made to develop cotton growing, but the results have not

been very satisfactory. Vast areas are composed of pasture lands and barren wastes, and, excepting the coast belt, the valleys of the Juba and Tana Rivers, and the Kavirondo district, much of the fertile land lies at too high an elevation for profitable cotton cultivation.

The largest amount of cotton exported in any one year was 1653 bales in 1923-24. The indigenous cotton plant *G. Kirkii* produces a short fibre of inferior commercial value and no attempt has been made to improve it. Experiments with Egyptian, Sea Island, American, and Caravonica cottons have been conducted at various centres. A fair amount of success has been attained with Egyptian cotton under irrigation in the Juba and Tana Valleys; elsewhere Upland cotton has given the best results.

Promising reports have recently been received of native cotton cultivation in the north Kavirondo district, adjacent to Lake Victoria. In 1924 the area of cotton planted in this region is estimated to have reached 40,000 acres. The extension of the Uasin-Gishu Railway, already referred to, should still further facilitate the development of cotton growing in this area.

The B.C.G.A. have established ginneries at Malakisi and Asembo, and different commercial firms have established them at Wamia, Sio, Kisumu, and Kibos.

In Kenya, seed cotton is only purchased by the ginner or his representative; competition is thus minimised, for the ginner has a monopoly of purchase within a five-mile radius of his ginnery, except in a township, where any ginnery may establish a buying store.

Seed for planting has been obtained from Uganda, but much of it is of a very mixed character. The cotton has a staple of 1 to $1\frac{1}{16}$ inch; it is irregular, generally rather weak, but of good colour, and is picked fairly clean.

COTTON PRODUCTION IN KENYA
(Bales of 400 lb.)

Season.	Crop.	Season.	Crop.	Season.	Crop.
1918-19	100	1920-21	500	1922-23	1200
1919-20	100	1921-22	417	1923-24	1653

There appears to be a possibility of also developing cotton growing in south Kavirondo, but unfortunately the natives are not good agriculturists, and transport is not good.

SOUTH AFRICA

Cotton has been grown in various parts of South Africa for many years ; as early as the American Civil War it was grown in the Eastern Province of Cape Colony. It is, however, only within the last few years that the industry has assumed any great commercial importance. Formerly it was principally grown by white settlers in the higher lands, where the climatic conditions are unsuitable for this crop, and the results were not satisfactory. More recently cotton has been planted at lower elevations, where the conditions are much more favourable ; but disappointment has resulted in some cases through the failure to plant the seed in time to prevent the early frosts of April and May destroying the ripening crop. The planting of impure seed, and the shipment of small parcels of cotton, have been reflected in the poor prices obtained for the crop from certain areas. Another deterrent has been the lack of facilities for transport, handling, and marketing the crop. Progress has been most marked in Natal. During 1918 Natal produced one-sixth as much cotton as the Transvaal, but in 1920 it produced five-sevenths as much. Local markets have now been established at Durban and elsewhere, and arrangements have been made for shippers of cotton to draw up to 90 per cent of the value of the cotton against shipments.

COTTON PRODUCTION IN SOUTH AFRICA
(In Bales of 500 lb.)

Year.	Crop.	Year.	Crop.	Year.	Crop.
1909	62	1915	430	1921	2,338
1910	62	1916	454	1922	4,017
1911	26	1917	486	1923	6,464
1912	64	1918	566	1924	8,248
1913	64	1919	1,488	1925	20,000 *
1914	142	1920	2,188		

* Estimated.

With a view to secure first-hand information as to the country's cotton-producing possibilities, the E.C.G.C. despatched an expert to tour the country in 1922-23, and from his report, and to which I am indebted for much valuable information on the subject, the following conclusions were arrived at: "(a) That South Africa has very great possibilities as a cotton-growing country, and that the efforts that were being made to develop it should have the corporation's fullest support; (b) that the expert technical staff then at the disposal of the Union Government was not numerically strong enough to deal with the large and particularly varied areas in which cotton growing is commercially possible; (c) that improved communications are essential."

Cotton-growing Areas.—What may be described as the principal cotton belt of South Africa is a strip of country that lies immediately to the east of the Drakensberg Mountains, from Zoutpansberg on the north to the Tugela River on the south. The most promising areas for cotton production are as follows: *Transvaal*—(1) Rustenburg-Waterberg, north of Rustenburg, (2) Spelonken, (3) Tzaneen-Selati, (4) Acornhoek, (5) Malelane, (6) De Kaap Valley, (7) Nelspruit and White River Settlement; *Swaziland*—(8) Bremersdorp, (9) Lobombo Flats; *Natal*—(10) Vryheid, (11) Tugela Valley; *Zululand*—(12) Empangeni, Induma, country between the Pongola River on the east and the Lobombo Mountains on the west, Huhluwe, south of the Unkusi River and west of the Lobombo Mountains; (13) *Transkei Territory* between the St. John's River and the Great Kei River, a strip of country 100 miles long between the limits of five and twenty miles from the coast. The total area of land suitable for cotton cultivation is estimated at 4 million acres. It is considered that the quantity of cotton that might be annually produced in these areas within twenty years, if suitable encouragement is given, is about 300,000 bales.

Climatic Conditions.—In the Transvaal considerable precautions are necessary to grow cotton profitably at elevations over 2500 feet, and elevations of 2000 feet and under are a much safer altitude. Taking into consideration the question of altitude and climate, the most favourable area is the low country between the Drakensberg and the Lobombo Mountains, where the elevation is less than 2000 feet;

it extends southwards from the Zoutpansberg through Barberton, Swaziland, and Natal into Zululand.

Below the Drakensberg the rainfall varies from 25 to 35 inches, while in Zululand it is 35 inches and over. There is also a large area that is regarded as being suitable for cotton production in Rustenburg and Waterburg districts, where the rainfall is from 15 to 25 inches. It is already being fairly extensively grown to the north of the Rustenburg district, at an elevation of 3500 feet, where it is necessary to sow in October in order to escape the early frosts. Still farther north, towards the Limpopo, there exists land at a low elevation where the summer temperatures are favourable for cotton, but the rainfall is light and precarious.

Fortunately the bulk of the rain falls during the summer months, which, of course, constitute the growing season. The rains begin in October, increase in volume until January, when they gradually decrease and practically cease altogether by the end of May. In Zululand and some parts of Natal the rainfall tends to continue too late in the season, but in the areas of the Transvaal and Swaziland it gradually lessens towards the end of the growing season, thereby checking vegetative growth and assisting the ripening of the bolls. There is a great variation in the rainfall below the mountains, both in different places and in the same year. Occasionally a drought of as long as six weeks occurs during the growing season, while heavy falls of rain, sometimes as much as 10 inches falling in a single day, do great damage to the growing crops.

Considerable losses are suffered from hail, and probably none of the cotton areas is entirely free from damage by this cause, but it is most prevalent at high altitudes. November and December are the worst months for hail, though it may also occur in March as well.

Where the rainfall is low, such as in the Rustenburg district and on the Lobombo Flats, it would be an advantage if irrigation facilities were available. Schemes have been projected for the Rustenburg district, and for the low country under the Komati, Usutu, Lomati, and other rivers; while below the Drakensberg there exist perennial streams from which water could be obtained at comparatively little expense, either by flow or lift.

Soils.—Extreme diversity is shown in South African soils, even in quite small areas. Light and heavy, rich and poor soils may be found in the same field, and practically every farm contains many essentially different soils.

A granitic soil with patches of loam is found in the Spelonken district, and a similar formation occurs in the Acornhoek district, with soils derived from sandstone, shales, and diorite as well. Granitic soils also occur in the Tzaneen-Selati district, as well as serpentine and greenstone. In the Malelane district are heavy soils derived from hornblende and schist; while granitic soils occur in the De Kaap Valley, and in the Nelspruit and White River districts. The formation is mainly granite with basic intrusions in north Swaziland, but sandstone occurs farther south. At Big Bend and south of the Usutu River, heavy dioritic soils are found. In the Vryheid district, large areas of rich loam occur, as well as good silts and light sandy soils. Between the Pongola River and the Lobombo Mountains in north Zululand, there are reported to be very fine soils. Near the Durban-Somkele Railway in Natal the soils are mainly light, and are derived from sandy shale, while others have been formed from conglomerates. Heavy black soils derived from norite are found to the east of Rustenburg, and in the west of this district there are rich loams derived from diabase. Northwards a norite and granitic formation occurs, as well as sand, shale, dolomite, limestone, and diorite.

The light sandy soils derived from granite and the sandy shales will doubtless give fair cotton crops with the addition of phosphatic fertilisers. As regards the former, this has been well demonstrated at the Rustenburg experiment station. The heavy clay soils of the Rustenburg district, although fertile, are difficult to work, and require heavy early rains to saturate them thoroughly for planting; but they are liable to water-logging if the rainfall is too heavy.

In selecting land for cotton planting, sloping lands should be avoided, because of their tendency to scour and erode with the heavy falls of rain that occur. The varied soils of the country require to be exhaustively studied both from a chemical and a physical point of view, and the information thus acquired should be made available for the use of farmers.

Land Tenure.—A part of the land has been reserved for

white settlers and a part for the natives. In Swaziland and Zululand large areas have been demarcated as native locations, and similarly, but in a lesser degree, in Natal. The Transkei is reserved almost exclusively for natives; each family has 10 acres of arable land as well as outside pasturage rights. A relatively small area has, however, been definitely assigned to natives in the Transvaal, for it comprises only 4 per cent of the total area of the Transvaal.

The Native Land Act of 1913 interdicts the purchase by a native of land outside native territory from a white man. As it was considered that the land reserved for the natives in the Transvaal was inadequate, the Native Land Committee, in 1917, recommended that further areas should be reserved for them, but no legislation has as yet been promulgated to give effect to this proposition.

Some of the land companies permit the natives to live on certain farms, also to run their cattle and to cultivate what land they choose, for the payment of £2 per annum for each effective adult male. On these terms natives have occupied definite areas for generations, and amongst themselves have established customary rights to particular plots of land. Obviously they have no permanent rights, and are merely tenants-at-will of the land companies. It is, however, unlikely that the owners of these estates would evict them, for they provide an invaluable supply of labour. These conditions prevail in the Spelonken, Tzaneen-Selati, and Acornhoek districts in the Transvaal below the Drakensberg, which are all promising cotton-growing areas. It is considered that practically the whole of the land in these districts is eventually to become native areas.

It is officially reported that land may be purchased at prices ranging from 10s. to 15s. per acre upwards, depending on the distance from the railway and the principal town. Further, that the average price to pay for a farm with good, non-irrigable land would be about £1 to 30s. per acre. The Government has recently thrown open for selection 100,000 acres of land, said to be suitable for cotton cultivation, in Zululand, at 25s. per acre, on very easy terms of payment.

Agricultural Conditions.—The principles of good tillage are commonly practised, though, paradoxical as it may appear, farming is new to many of the farmers; for they have been

principally engaged in stock-keeping, and this industry is likely to remain pre-eminent for some time to come. Certainly until quite recently very few of the farmers had any experience of cotton cultivation, and it is therefore not surprising that many mistakes have been made. Many failures have been due to the selection of unsuitable land, for there existed a prevalent though mistaken idea that the light soils were best suited for cotton growing. Other defects have been the planting of steep land subject to surface washing, and too deep ploughing when the land was first broken up. In the latter case the weathered soil was deeply buried, and the raw subsoil was brought to the surface; whereas it is obviously more efficacious to postpone deep cultivation on new land for several years.

Groundnuts provide an excellent rotation crop, but systematic crop rotation is not generally practised, and few fertilisers are used. Green manuring is adopted to a certain extent. Generally a farmer has ample land to choose from, as most farms comprise several thousand acres.

The white settler organises and directs, but the manual labour of agriculture is practically all done by natives. In most districts the white settler procures sufficient labour for the permanent work of the farm by permitting Kaffir families to settle on the farm. They enjoy the privilege of running their cattle and cultivating certain portions of the farm for their own benefit, provided they give three months free labour each year in return. Provided suitable arrangements are made, a settler who understands the native and impresses him favourably, is generally able to procure an ample supply of labour. This applies not only to male adult labour but to women and children for picking the crop. It is considered that the existing supply of labour suffices for a fairly rapid extension of cotton production in most districts for some time to come, more especially as the native population is increasing rapidly. It is officially reported that, generally, native labour for cotton growing is fairly plentiful at prices ranging from £1 to £2 per month for each adult male.

It has been suggested that the native tenants of land companies should be encouraged and assisted to grow cotton on their holdings. This appears to be feasible, for these companies have a great hold on their native tenants, and the

latter are attached to their holdings and have no desire to leave them. There are no white farmers to employ labour in the Transkei, but there is a possibility that the natives may be encouraged to grow cotton on their own farms. As regards the feasibility of developing a scheme of this kind in Swaziland and Zululand, there appears to be little prospect at present. In Swaziland, attempts were recently made along these lines, but have been abandoned as impracticable. The natives are conservative in their habits and are suspicious about the price that may be paid to them for cotton. They understand maize cultivation, but know nothing about cotton. They have ample land for their stock and are able to grow as much maize as they desire. Most of the field work is done by the women, and, when the necessity arises, the men can always obtain work on neighbouring farms or in the towns and mines.

The extension of cotton growing in the near future is therefore likely to depend primarily on the white settler. In other parts of Africa natives have been successfully encouraged to grow cotton in considerable quantities, so that in course of time similar success may be attained in South Africa.

The staple agricultural industries are cattle breeding and maize growing. In regard to the former, it should be observed that there is always a danger of a glutted market through over-production. Low-country farmers agree that it is exceptional to grow maize profitably over and above what is required for consumption on the farm, for transport runs away with the profit on such a low-priced article. Moreover, maize needs more rain than cotton, which is to the advantage of the latter in the drier tracts; still, maize will continue to be the staple crop for some time to come. In certain districts of precarious rainfall, if the early rains are inadequate for early cotton planting, maize is substituted because it matures more quickly. It is possible that groundnuts may be more extensively grown in the future, but this is not to be deprecated in view of their value in rotation with cotton.

Having regard to all the circumstances, cotton is likely to prove a profitable crop in the areas mentioned, and is not likely to suffer in competition with other field crops. Unfortunately, in certain of the areas, communications are

very unsatisfactory, and considerable expenditure will have to be incurred on road making and railway extensions. Government has sanctioned railway extensions northwards from Somkele to the Pongola River, so as to encourage cotton production in Natal and Zululand. A great deal of cotton is already produced in this region, but the additional transport facilities that will be provided by this extension should open up the country for a considerable development of the industry.

Cotton-growing Problems.—Various kinds of Upland, Egyptian, and Sea Island cotton are under cultivation, but, unfortunately, they are not grown pure, for the seed has become hopelessly mixed. Different varieties may be seen growing side by side in the same field, and hybridisation has taken place to a considerable extent. This mixture not only depreciates the value of the product, but it involves difficulties in ginning as well. The matter of providing an adequate supply of pure seed for planting purposes is urgent. Pure line breeding under competent botanical supervision is one of the most pressing problems that need attention. That research work of this nature would be likely to yield profitable results is indicated by the circumstance that fairly pure commercial samples of Upland cotton have been valued at 300 points on “American middling”. It is considered that to ensure a ready market for the crop a staple of $1\frac{1}{8}$ to $1\frac{3}{16}$ inch should be aimed at.

A cotton geneticist commenced investigations in 1924 and good results are anticipated ; but as the work of breeding is necessarily slow and tedious, growers are advised to carry out mass selection work for themselves, at any rate for the present.

Soil and climatic conditions necessarily vary to an enormous extent in the different areas, so that it is essential to discover the variety or varieties that can be most profitably cultivated in particular areas.

In a great part of the Transvaal an Upland variety known as Improved Bancroft is grown. Other varieties in use are : Watt’s long staple, Zululand hybrid, Uganda and Nyasaland cotton. In the Vryheid district of Natal and Zululand, the Zululand hybrid is largely grown ; in other parts of Natal, Griffin is favoured.

The Department of Agriculture has conducted field trials

with cotton at the Rustenburg experiment station and at the gaol garden at Barberton. Of many varieties tested at the station, Bancroft has been selected as the one best suited for the district; preliminary grading of the 1923 crop showed an average staple of $1\frac{3}{8}$ inches. Experiments with Pima Egyptian cotton, under partial irrigation, gave a yield of 1386 lb. of seed cotton per acre on a plot of $1\frac{3}{4}$ acres, the staple length being $1\frac{1}{2}$ inches.

Problems connected with preliminary cultivation, inter-culture, and spacing the plants have been studied, as well as the effect of fertilisers on light sandy soils. In regard to the last mentioned, the rotation adopted was: maize, tobacco, cotton, and green manuring. It has been demonstrated that the application of acid phosphate, at the rate of 200 lb. per acre, once in a rotation, at a cost of 18s., results in a marked increase in the yield of cotton and other crops, and shows a good profit. It is considered that the large stores of cattle manure accumulating in the numerous cattle kraals throughout the country might be advantageously used for cotton cultivation and to increase the supply of winter cattle food in the form of cotton seed.

The E.C.G.C. has secured the former Agricultural Adviser to the Government of India as their expert in South Africa, as well as an experienced plant breeder, and other officers are to be appointed as the necessity arises. Research work is already being conducted by the Department of Agriculture in conjunction with the Transvaal University College.

Cotton Yields.—Taking the country as a whole, it is estimated that an average yield of 150 lb. to 180 lb. of lint per acre may be expected. For the season 1923–24 the average yield of seed cotton throughout the country was 428 lb. per acre. During the seven years 1916–23 the yield of seed cotton at the Rustenburg experiment station has varied from an average of 268 lb. to an average of 1182 lb. per acre; the average for the whole farm for the period being 647 lb. per acre. During this period the average ginning percentage of lint varied from 29·8 to 33·08.

A farmer in the Rustenburg district has reported that in a good season he got as much as 1400 lb. of seed cotton per acre on 10 acres, whereas in a dry season, with only 15 inches of rain, he got an average of 500 lb. of seed cotton per acre.

Careful records kept by sixteen farmers in this district show that their average yield during a dry season was 300 lb. of seed cotton per acre.

At the Mpako experiment station in the Transkei, on 30 acres the average yield of Upland seed cotton, during three years, was 425 lb. per acre. There appears to be a possibility of growing long staple cotton in this area, for an average yield of 1200 lb. of Sea Island seed cotton per acre has been recorded from an area of 4 acres at Mpako.

In the low country below the Drakensberg, where the rainfall is more favourable, yields of 900 lb. of seed cotton per acre are commonly reported. A cotton farm of 450 acres in the Tugela Valley, Natal, is reported to have given an average yield of 1200 lb. of seed cotton per acre.

Insect Pests and Diseases.—The most serious insect pests are the American boll-worm, *Chloridia obsoleta*, the spiny Egyptian boll worm, *Earias insulana*, and the Sudan boll worm, *Diparopsis castanea*. Aphis is troublesome, especially during spells of dry weather. Grasshoppers do a certain amount of damage, as well as two *Dysdercus* cotton stainers and cut worms. All these are common pests in most cotton-growing countries, and at present there appears to be no reason to anticipate any serious menace to the industry from them. Fortunately the pink boll worm and the Mexican cotton boll weevil have not been recorded, and Government enforce strict measures to prevent the introduction of these pests with imported seed.

As regards fungus disease, anthracnose has been reported ; otherwise cotton appears to be singularly free from maladies of a fungoid nature.

Handling and Marketing the Crop.—As mentioned before, farmers have experienced difficulty in getting their crop ginned and marketed. Small ginneries exist in the Malelane, Acornhoek, and Spelonken districts. In Rustenburg and Durban, co-operative societies operate ginneries and undertake to market cotton for members, but they have been so unsuccessful on several occasions that farmers have lost confidence in them. There are also commercial ginneries at Pretoria, Bremersdorp, and near Durban. With one exception, saw gins only are used. These ginneries cannot be said to serve any large tract of country in an effective manner.

Seed cotton has had to be sent 300 miles to Pretoria for ginning, and the lint then transported 500 miles to Durban for shipment. This of course involves unnecessary expenditure on railway freight. Owing to lack of experience, much bad ginning has been done, resulting in badly cut lint and badly cleaned seed. Recently, however, ginning facilities have been greatly improved, and there are now twenty-four ginneries in operation.

The presses in use were unable to produce a density greater than 15 lb. to the cubic foot, and the size of the bales were not uniform; improvements have also been made in this connection.

The charges for ginning and baling have been about $1\frac{1}{4}$ d. per lb. of lint, but recently competition has caused certain ginneries to reduce their charges to $\frac{3}{4}$ d. per lb. The total cost of ginning, baling, and marketing has amounted to as much as 2.072 to 4.507d. per lb. of lint.

The natural port for cotton grown in the Transvaal and north Swaziland is Lourenço Marques, while for that grown in Natal, Zululand, and south Swaziland, Durban is the natural port.

It is proposed to establish a strong commercial association with the support of the Union Government and the E.C.G.C., which would erect a central ginney and press at Koomatipoort to serve the areas on the Selati line, and between Nelspruit and Koomatipoort, and the De Kaap Valley as well. Organisations of this nature are much needed to buy the seed cotton outright at a fair price, or to undertake its efficient ginning, baling, and marketing; also to arrange for the lumping together of small individual parcels of cotton, which, when offered for sale separately, cannot compete with similar grades of American cotton that are always available in large parcels. They should likewise be able to aid in the maintenance of a pure seed supply.

All ginneries must be registered, and Government has passed a law requiring all cotton to be pressed to a uniform density, and standardising the 500-lb. bale.

Cotton Grading.—All cotton for export must be graded by a Government grader—a charge of 1s. per bale being made for grading. The grader's typemark, as well as the ginner's mark, must be shown on each bale.

Formerly serious complaints had been received from purchasers as to mixed packing and lack of uniformity in shipments. Preliminary classification of seed cotton was therefore undertaken at the ginneries, where the seed cotton is collected in wool packs of 400 to 500 lb., and is grouped for ginning according to: (1) staple, (2) cleanliness, and (3) colour. The wool packs are marked in conformity with the classification, only those carrying the same marks, and, as far as possible, from one grower, being ginned together. To overcome any slight variation in the different wool packs, three or more are fed to the gins at a time, so as to average the cotton and obtain uniformity.

The regulations governing grading provide that samples be taken as follows:

“ One portion from the cotton lint filling the bottom of the press-box, another portion when the press-box is half full, and a third from the top layers of the press-box. The three portions together should weigh about $\frac{1}{2}$ lb., and must be laid one on top of the other and wrapped tightly in a sheet of paper; each sample must be marked with the same mark and number as the bale which it represents; provided, however, that it shall be competent for the Chief, Tobacco and Cotton Division, in his discretion to substitute other methods of taking samples in cases in which he deems it desirable to do so.”

This method of sampling ensures that the sample is representative of the bale; the bale is not rendered unsightly by slashing for samples, the contents are fully protected, and patching and the increase of the tare of the bale which it entails is obviated.

Grading is based on Liverpool classification for American cotton, the “ 1924 Universal Standards ” serving as a basis; for the bulk of South African cotton consists of American Upland types. Type samples are distributed among all oversea and local firms known to be interested in South African cotton.

Sales are usually effected on Government grading certificate, and samples submitted for confirmation to the buyer. The necessity to ship cotton on consignment has already disappeared, and it is anticipated that as soon as the crop is sufficiently large to enable lots of, say, 100 bales

to be offered it will probably be possible to sell on type by cable.

A grading certificate, in triplicate, is issued in connection with each lot of cotton graded, and prior to the export of the cotton a copy must be handed to the port authorities.

A levy of 1s. per 100 lb. of lint is imposed on all cotton exported; the proceeds from this levy is to be applied to the industry's improvement.

The disposal of the seed is another matter which will have to be dealt with, for at present the local demand for it is very limited, and if it were exported transport would swallow up most of the money realised by sales. It would cost about £6:10s. per ton to place it on the market, whereas American cotton seed sells in Hull for £8:5s. per ton.

It is probable that the difference in season between America and South Africa may be an advantage to the South African farmer, for his crop is ready for market in the summer months, when European stocks are normally at their lowest.

It is interesting to observe that South Africa imports about £3,500,000 worth of manufactured cotton products annually, so that in course of time she may be able to supply much of her own requirements.

Production Costs.—Careful records kept at the Rustenburg experiment station for two years show that cotton production cost £4:12s:7½ per acre, including ginning and baling. The cotton was grown at a profit of £1:6:8 and £1:7:5½ in the two seasons 1915–16 and 1916–17 respectively. One of the largest growers estimates that he can put cotton on the market at 6d. per lb., and that every additional penny that it realises over the 6d. adds a profit of £1 per acre to him. This estimate is in agreement with that of several other competent local observers. An official estimate places the cost of producing a crop of cotton at £4 per acre; this amount being required to prepare the land, plant, cultivate, and harvest the crop. The cost of clearing land for cotton is given as £1 per acre, but this charge will necessarily be higher if the land is densely covered with bush and tree growth.

The subjoined estimate of the cost of cotton production in South Africa was prepared by the E.C.G.C.'s expert in consultation with the manager of the estates which grow the largest individual area of cotton in the country; in 1924 these estates had over 9000 acres of cotton under cultivation.

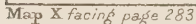
100 ACRES COTTON ON CANDOVER ESTATES, NATAL, 1921

<i>Rates</i>			
	£ s. d.	£ s. d.	£ s. d.
Farmer's Capital :			
18 oxen	8 0 0	144 0 0	
Trek gear	..	10 0 0	
1 double plough	..	25 0 0	
2 cultivators	7 0 0	14 0 0	
1 planter	..	20 0 0	
1 waggon	..	60 0 0	
1 drag harrow	..	7 0 0	
1 disc harrow	..	20 0 0	
12 hand hoes	0 3 0	1 16 0	
1 scale	..	1 5 0	
1 horse	..	15 0 0	
Cotton sacks	..	2 10 0	
			320 11 0
Interest on £320 at 10 per cent	..	..	32 0 0
Depreciation on £176 at 12½ per cent *	..	..	22 0 0
Cotton seed 25 lb. per acre at 2d. per lb.		..	20 0 0
Labour :			
6 men for six months . . . £2 per month		72 0 0	
Hoeing and thinning	..	10 0 0	
Picking 40 bales 2s. per 100 lb. seed cotton		60 0 0	
Hauling cotton to ginnery	..	6 0 0	
Hauling lint to railway station (72 miles)	..	20 0 0	
			168 0 0
Ginning and baling 40 bales . . . 1d. per lb.		..	83 0 0
Stock feed	..	nil	
Supervision	..	..	180 0 0
Value of Crop :			
20,000 lb. 7½d. per lb.		625 0 0	
20 tons seed	..	50 0 0	
			675 0 0
Less rent Interest at 10 per cent on £500, re- presenting value of the land		50 0 0	
			625 0 0

* No depreciation is debited to the oxen, since they are eventually destined for beef.

Scale of Miles
50 0 50 100 150

Cotton Areas
Railways open
" proposed or
in course of construction



The estimated area planted with cotton in 1924-25 is given below :

	Acres.
Natal and Zululand	30,500
Rustenburg, including Pretoria and Marico districts .	10,000
Northern Transvaal, including Waterberg, Pietersberg, and Zoutpansberg districts	10,000
Eastern Transvaal, including Middleburg, Lydenburg, and Barberton districts	11,000
Cape Province	3,000
Swaziland	3,000
Total	<u>67,500</u>

RHODESIA

During the last twenty-five years intermittent efforts have been made to develop a cotton-growing industry in Rhodesia, and a considerable number of experiments were conducted, but comparatively little progress was made until quite recently. Formerly the low price of cotton precluded its being grown in competition with such crops as maize and tobacco, especially in view of the heavy transport rates prevailing, but the rise in the price of cotton has caused increased interest to be taken in the industry.

Many parts of the country are well adapted to cotton cultivation, but, unfortunately, a large portion of the most suitable lands are situated in the more remote and unsettled regions, where transport is lacking or is too costly for cotton to be profitably grown. The country's cotton-producing possibilities require to be carefully investigated by competent experts, and the most promising areas should be exhaustively tested by properly conducted cotton-growing experiments to determine the types of cotton that can be most profitably grown.

SOUTHERN RHODESIA.—The area of Southern Rhodesia is 153,250 square miles, and it has a population of 33,620 Europeans and 862,000 natives. The mean rainfall of the whole country is 28·2 inches, but over the greater part of the country it varies from 25 inches to 40 inches, and is favourably distributed throughout the summer months. The mean annual temperature is 66° F., with a mean annual minimum of 54° F. and a mean annual maximum of 78° F. In the hot

lowlands, where the rainfall is scanty, there are good prospects for irrigation.

As regards transport, it is interesting to observe that one-third and one-quarter of the country lie within twenty-five miles and twenty-five to fifty miles of the railway respectively. There are 2 million head of cattle in the country, and both these and horses are freely used for transport and tillage operations.

Land available.—Government land suitable for cotton growing, practically ready for the plough, and situated some thirty or forty miles from a railway, can be bought at from 4s. to 10s. per acre, on easy terms of payment, while the land-owning companies charge from 15s. to 25s. per acre for land up to fifteen miles from the railway. About one-half of the country is unalienated, one-fifth is owned and occupied by Europeans, a similar area consists of native reserves, and the remainder is privately owned but is not yet utilised. It will thus be seen that there is ample scope for further development.

Land is held under a variety of titles, but on the general basis of freehold ownership acquired by purchase, subject to reasonable stipulations as to occupation and development. The acquisition of title presents no difficulties, for land is readily bought and sold and given as security for loans on mortgage.

Increased Interest in Cotton.—In 1923–24 a revival of cotton growing took place ; 55 tons of American Upland cotton seed were imported from South Africa, and nearly 4000 acres were planted, of which 1262 acres were planted in the Mazoe district. Other districts where cotton is grown are : Hartley, Lomagundi, Makoni, Wankie, Gwanda, Bubi, Bulawayo, Victoria, Nyamandhlovu, and Melsetter. The average yield of seed cotton was 428 lb. per acre, but individual yields were obtained as high as 1000 lb. and even 1500 lb. per acre. The production of lint amounted to 1600 bales of 400 lb. each, and its quality has been favourably reported on. The staple of the cotton ranges from $1\frac{1}{16}$ to $1\frac{1}{8}$ inches. The chief variety grown is that known as Improved Bancroft. A specialist in plant breeding has been appointed with a view to conduct experiments to ascertain whether some other variety may be even better adapted to the local conditions.

The area under cotton increased in the following year to

65,000 acres. A ginnery has been erected at Salisbury, the capital of the country, and also at Untali and Gwelo. Arrangements have been completed for the provision of other necessary ginneries by the Government, the E.C.G.C., and the B.C.G.A. jointly to deal with the 1924-25 crop, which is estimated to amount to 20,000 bales, and ginneries are now in operation at Bindura, El Dorado, and Gatooma.

The whole crop is grown by Europeans with the assistance of native labour. Although Southern Rhodesia lies within the tropics, owing to its high elevation the climate is almost temperate, with a cool dry season, when at night there may be a touch of frost. Planting takes place at the commencement of the warm, rainy season in November. Normally the rains cease at the end of March; a fall in the temperature then occurs which checks plant growth. Cotton picking takes place from April to August.

The experience so far gained in Southern Rhodesia indicates that cotton can be successfully grown on a far greater area than was originally supposed. Further, that the optimum conditions are loamy soils, altitudes up to 4000 feet, and rainfall of 18 to 30 inches. The farmer is, however, still in the apprentice stage and he has much to learn as to cultivation and crop improvement.

The success that has been attained in cotton growing has given an impetus to land settlement. As labour is both plentiful and cheap, it is anticipated that cotton production will continue to increase for some years to come, for there are already 2400 farmers established on the land. A good market is assured for cotton-seed cake for cattle-fattening purposes, while cotton-seed oil can be utilised locally in place of present imports. In rotation with maize, which is at present the colony's most important agricultural staple, cotton will occupy an important position in the farm routine. In regard to pests, the country is fortunate in being free from the pink boll worm and the boll weevil, although cut worms, aphids, cotton stainers, and Sudan boll worms are fairly prevalent.

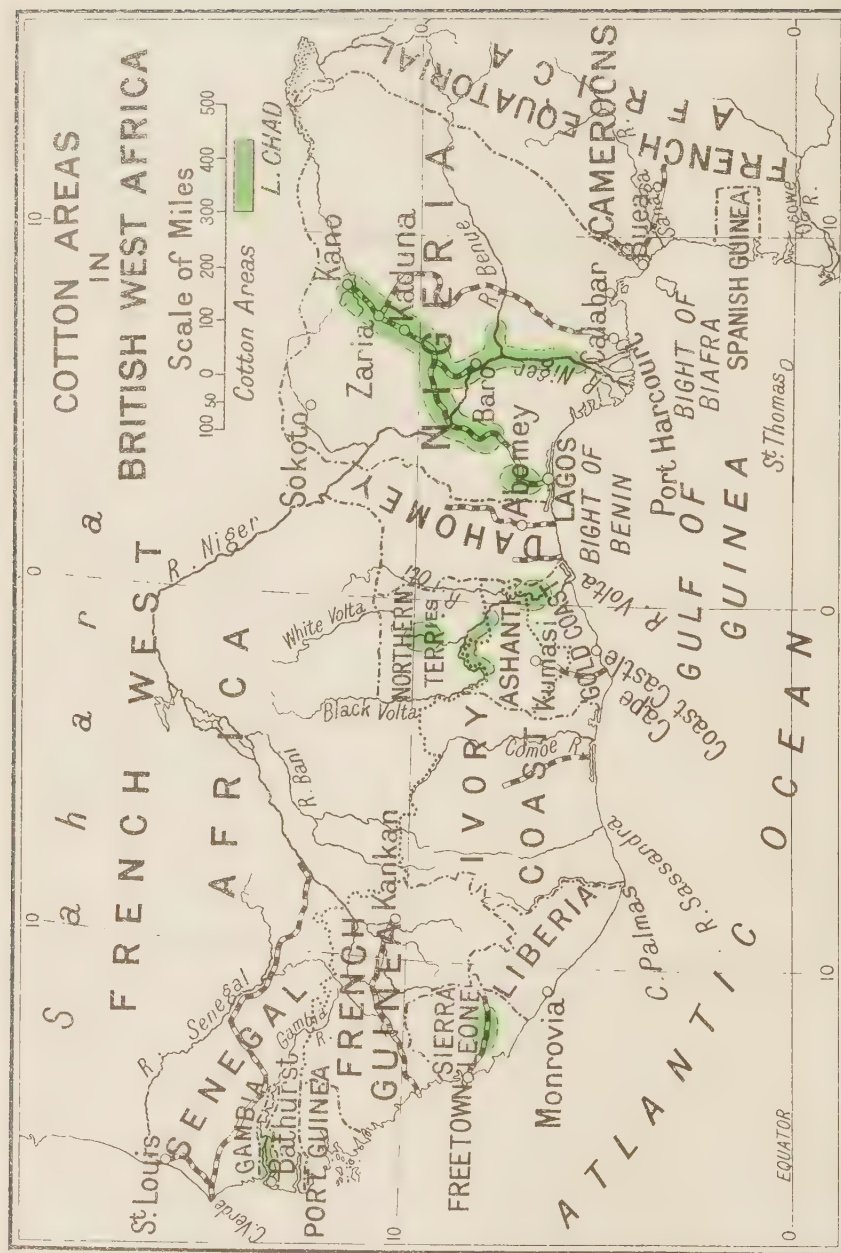
NORTHERN RHODESIA.—In the period 1908-17 cotton-growing experiments were conducted north and south of the Kafue River on the Livingstone-Broken Hill Railway in Northern Rhodesia. In 1910 the B.C.G.A., in co-operation

with the British South Africa Company, erected a ginnery and a hydraulic press at Mazabuka, where a small cotton plantation was likewise established. Some 200 acres were planted with cotton, but owing to the attacks of white ants and labour difficulties the results were not altogether satisfactory. Eventually the B.C.G.A. withdrew from the experiment and the British South Africa Company finally took over the ginnery and the plantation.

Experiments were likewise carried out at Fort Jameson, in what was formerly known as North-Eastern Rhodesia, and there seems every reason to hope that when better transport facilities are available a considerable quantity of cotton might be grown in this area. The suggested extension of the Nyasaland Railway would probably assist in improving transport in this region.

The increase in the price of cotton has likewise had the effect of causing increased interest to be devoted to cotton cultivation in Northern Rhodesia. It is considered that 100,000 acres could be planted with cotton on suitable land within a reasonable distance of existing railway facilities.

In 1924, 500 bales of cotton were produced, and it is estimated that, in 1925, 21,000 acres were planted with cotton, and that the total production will amount to 6000 bales. Arrangements have been made for the necessary ginning and baling facilities to be provided at Mazabuka, and Regulations have been passed by Government to regulate the grading and classifying of all cotton intended for export.



CHAPTER IX

COTTON PRODUCTION IN THE BRITISH EMPIRE (II) OTHER THAN INDIA.

West Africa. Nigeria: Geography—Climate—Physical features—Communications—Agricultural conditions—Experimental plantations—Moor plantation—Maigana Farm—Pests and diseases—Handling and marketing the crop—Summary. Gold Coast. Togoland (Mandated). Sierra Leone. Gambia. West Indies: The cotton industry—Cotton produced in the various islands—Pests and diseases—Cotton cultivation and marketing—Yields—Ginning and baling. British Guiana. Iraq, Mesopotamia (Mandated): Great agricultural potentialities—Soil, and effects of salt—Irrigation—Transport—The cotton industry—Experimental work—Impending developments. Cyprus. Malta. Ceylon. Malaya. Fiji. Australia: Geography and climate—Early efforts to promote cotton growing—Recent investigations—Pests and diseases. Queensland: Government crop price guarantee—Handling the crop—Cotton grading—Production costs—Area and yield of cotton—Land tenure—Cotton cultivation—Plant breeding and research work. New South Wales. Western Australia. Northern territory. Irrigation settlements. Exports of Australian cotton.

WEST AFRICA

COTTON has probably been grown in West Africa for a thousand years and used for the manufacture of the cloths with which the natives clothe themselves, and for export in large quantities, by river and caravan, as far north as the Mediterranean. It is estimated that fully 70 per cent of the cotton grown in West Africa is still consumed locally. Cotton for these cloths is ginned by hand, spun into yarn, and woven on simple looms into narrow strips, that are sown together to form the size of cloth required. These cloths are very durable, and are frequently artistically decorated by the use of yarn variously coloured with different native dyes. It is reported that, in 1857, from 1000 to 2000 head-loads of cotton were offered for sale, on large market days, at the village of Ila, near Ilorin, Nigeria.

As early as 1851, a Manchester merchant attempted to

encourage the West African natives to grow cotton for export. In 1853, he imported from West Africa 37 bales of cotton, each of 120 lb. in weight ; six years later the exports had risen to 3500 bales. In 1869 Nigeria alone exported cotton to the value of £77,000.

At the time that the B.C.G.A. was inaugurated, West Africa was looked upon as the most promising field in the Empire for developing a new and large source of supply for the Lancashire mills, and for several years it was to this part of the world that the Association devoted their major efforts. Unfortunately cocoa proved a serious competitor to cotton in the Gold Coast, groundnuts played a similar rôle in Gambia, and excessive rain has been given as the cause of failure in Sierra Leone. Of late years the Association have concentrated their efforts in West Africa on Nigeria. The total exports of cotton from British West Africa in 1924 amounted to 25,000 bales of 400 lb. each, all of which emanated from Nigeria. Lord Palmerston's prophecy to the effect that the West Coast of Africa would eventually produce more cotton than all other countries except the United States therefore appears to be as far off accomplishment as ever.

Conditions that are essential for the development of cotton growing in this region are : (1) The provision of suitable transport facilities ; (2) the instruction of the natives in the cultural methods best adapted for particular districts ; (3) the supply of pure seed of the varieties that can be most profitably grown, and, most important of all, (4) the assurance that the farmer will receive a fair price for his crop.

In all the West African colonies there are rivers capable of irrigating enormous tracts of land well suited for cotton cultivation, and where the deterrents mentioned above do not operate. Large areas of land are capable of irrigation by the Niger, Kaduna, and Benue Rivers in Nigeria, and the Volta River in the Gold Coast. Under irrigation, cotton could be grown during the dry season, when the climate is for the most part more favourable for the crop than the hot, moist atmospheric conditions that prevail during the rainy months that at present constitute the growing season. The vagaries of the West African climate have always been one of the limiting factors in West African cotton production ; it is therefore probable that it will be by means of irrigation that the long-

cherished West African cotton industry will be eventually developed.

NIGERIA

Geography.—Nigeria is without doubt one of the most promising fields for cotton production in the Empire. It is enclosed by parallels 4° and 14° N. lat. and by meridians 3° and 14° E. long. It is bounded on the north by the French Sudan, on the east by French Equatorial Africa and the Cameroons, on the south by the Atlantic Ocean, and on the west by Dahomey and the French Sudan. The territory extends from the Bight of Benin, in the Gulf of Guinea, to Lake Chad, bordering on Central Africa; and from the Bight of Biafra, also in the Gulf of Guinea, to the confines of the French possessions in the Middle Niger. The upper regions of Nigeria lie well within the Western Sudan.

Nigeria's greatest length from east to west is 700 miles, and its greatest breadth from north to south is 650 miles. The area of the whole country is approximately 346,000 square miles, or about one-fifth the size of British India. The coloured population is estimated at $18\frac{3}{4}$ millions, while the white population is approximately 2500. The population is thus larger than that of any British Dependency excepting India, and is larger than that of South Africa, Tanganyika, Nyasaland, and Uganda put together. The density of population is 54 per square mile, but it varies enormously in different districts from 363 per square mile in Onitsha to only 6 per square mile in Kontagora.

Climate.—The rainfall ranges from 28 inches in the Northern Provinces to over 150 inches in the Delta Region. The rainy season extends from April to October. In the Southern Provinces, the average temperature is $78\cdot5^{\circ}$ F., while that of the Northern Provinces is 80° F. During the dry season, a hot, dry wind, known as the "Harmattan", blows across the country from the Sahara, bringing with it a fine dust that produces a hazy atmosphere.

Physical Features.—The country is comprised of four principal zones, each of which possesses characteristics peculiar to itself. (1) A zone of swamp and mangrove forest with dense undergrowth, which runs parallel to the coast-line and varies in depth from 20 to 60 miles. It

includes the deltaic region of the river Niger and is traversed by a network of rivers and creeks. (2) A belt of dense forest with thick undergrowth, which extends from the western to the eastern boundary, and for from 50 to 100 miles in width. This zone is well watered by numerous rivers. The country is generally undulating with scattered hills, some rising to over 3000 feet. (3) A zone of comparatively open country, gradually developing into park-like land; followed by open expanses covered with high grass as the watersheds of the rivers Benue and Niger are approached. It is generally hilly and even mountainous on the Cameroons frontier, where heights over 6000 feet occur. (4) An enormous plateau occupies the greater portion north of the rivers Niger and Benue, where many rivers take their rise. Its altitude is not much over 2000 feet, except in the Bauchi Province, where heights of 6000 feet are found. The country is generally undulating, and to a large extent is clothed with thin forests, which become sparser as the Western Sudan and the arid "steppes" of the Sahara Desert are approached.

Communications.—The most important river is the Niger, which flows south-east throughout the country; at Lokoja, some 300 miles from its mouth, it is joined by the Benue, which rises in the Cameroons. The Niger is navigable by steamers as far as Lokoja at all seasons, and as far as Jebba during the rainy season. The Benue is only navigable by steamers for three months in the year. The Niger and its tributaries are navigable for their entire length by canoes during the rainy season.

The country is inadequately supplied with railways. The principal line runs in a north-easterly direction from the port of Lagos to Kano, a distance of 705 miles. A branch line from Baro, on the Niger, connects with the principal line at Zungeru, a distance of 111 miles; while a light branch line connects Bukuru with the main line at Zaria, a distance of 144 miles. A new railway has been built from Port Harcourt *via* the Udi coalfields to Jaginde, a distance of 433 miles, and it is proposed to extend this to meet the Lagos—Kano Railway at Kaduna.

In the Southern Provinces motor lorries are used to a certain extent as feeders to the railway, but the capacity of the lorries is much limited by the unsubstantial nature

of the roads and bridges over which they have to travel. In the Northern Provinces there is an excellent Government motor transport service from Zaria to Gusau, Zaria to Sokoto, and Bukuru to Ropp, and several commercial firms are running a series of motor lorries.

Pack and draught animals are not employed in the Southern Provinces, chiefly owing to the prevalence of tsetse-fly ; but in the Northern Provinces camels and donkeys are employed to a considerable extent for transport purposes. Camels carry a load of 400 lb. and donkeys 150 lb. Although cotton growing is chiefly confined to the districts served by the railway and the Niger and Benue Rivers, the movement of the crop involves an enormous amount of head-transport by native carriers, which is most uneconomical and is a serious tax on the industry's development, for provision of improved transport facilities would set free a large number of carriers for more extensive cotton production. Transport has always been, and will probably continue to be for many years, the limiting factor in the industry's development.

Agricultural Conditions.—Agriculture is the staple industry, and probably no country in the world has a greater proportion of its population dependent on the soil for its livelihood. There are no white farmers in the country, and no large native farmers. Prior to British rule, a comparatively few natives, who owned large numbers of domestic slaves, farmed considerable areas of land, but the abolition of slavery put an end to this. Although over three million head of cattle, principally owned by nomadic Fulani, exist in the northern portions of the country, comparatively few are kept regularly on the farms, and they are not employed for cultural operations. In many parts of the country the prevalence of tsetse-fly is a serious obstacle to cattle breeding. Consequently as hired labour is little used, the cultivated areas are small, rarely exceeding 2 or 3 acres. It is essentially a country of small-holders or peasants, and the communal system of land tenure in vogue restricts development by a new class of large landowners.

The nature of the climate renders even the most ordinary soil fertile, and as there is generally an abundance of land available for the shifting cultivation practised, little or no manure is used. Bad food-crop seasons rarely occur. A

farmer is thus able to grow, with little difficulty, sufficient for his own domestic requirements, and a surplus for sale where-with to purchase his other limited needs. Owing to the expense of transport, the production of exportable produce is mainly restricted to a distance of 30 or 40 miles from the railway or a navigable river.

The native is intensely conservative, and his cultural methods are essentially primitive ; but it is important to bear in mind that these methods are on the whole well adapted to the local conditions, and that their adoption has resulted from hundreds of years of local experience. Extreme caution will therefore have to be observed in the introduction of modern agricultural methods, even when their advantages have been amply demonstrated by exhaustive experiments under local conditions.

The principal agricultural implements in use are a curved, short-handled hoe and a cutlass. The latter is employed to cut down trees and bush when land is being cleared, and at times to cut down weeds in the cultivated areas. With the former are performed all the other simple operations that are considered necessary for the crops. Usually the same piece of land is not cultivated for more than three consecutive seasons ; it is then allowed to lie fallow for periods varying from 5 to 10 years. One great advantage attaching to this system of farming is that it tends to keep insect and fungus pests in check.

When land is being cleared for a new farm, the small trees and undergrowth are cut down, but no attempt is made to extract the root-stocks. Trees of economic value, such as oil palms, rubber, and cola, are almost invariably spared. When the brushwood has dried sufficiently, it is fired, and the resultant ashes serve as a fertiliser for the crop that is planted later.

Generally the farmer looks upon cotton as a crop of secondary importance as compared with his ordinary food crops. In most cases it is planted intermingled with various other crops such as yams, sweet potatoes, legumes, maize, ground-nuts, and egusi, a cucurbitaceous plant. Small mounds of soil are made at varying distances apart, and ten or twelve cotton seeds are sown in each mound. Frequently as many as ten plants may be seen struggling for existence on one of

these mounds, and overcrowded by other crops and weeds. The planting season extends from June to the end of July. Picking begins in November or December.

The so-called native cottons are chiefly forms of *G. vitifolium* and *G. barbadense*, both naked-seeded cottons, and woolly-seeded cottons derived from *G. mexicanum*; *G. punctatum*, var. *nigerica*; *G. obtusifolium*, var. *africana*; *G. arboreum*, var. *sanguinea*; and *G. peruvianum*.

In many cases the ripe cotton is allowed to remain on the plants too long, and is injured by climatic influences, which both weaken and discolour it, or it falls to the ground and is either abandoned or, if collected, becomes contaminated with dirt, dry leaves, and other impurities. Often insufficient care is taken to keep the cotton clean and dry after collection; it is stored in leaky huts, and during the buying season, packages of cotton may be seen exposed to the rain in the local markets. Through lack of proper facilities, cotton is also sometimes unduly exposed to the weather at railway stations and in open railway trucks.

Experimental Plantations.—The first experimental cotton plantation was established in 1841, under the protection of the Admiralty expedition sent out in that year, near the confluence of the Niger and Benue Rivers, but little success attended this venture. In 1889 the Royal Niger Company carried out cotton-growing tests at Abutshi (Asaba) on the Niger, but without definite results. Shortly after its inauguration, the B.C.G.A. established experiment farms at Moor Plantation (Ibadan), which is situated on the railway, 120 miles distant from Lagos, and at Illushi on the Niger. The latter farm was abandoned in 1910 without any very definite results being recorded.

Moor Plantation.—At Moor Plantation the Association experimented with different varieties of Egyptian, Sea Island, American, and native cottons, with a view to decide as to the variety that could be most profitably cultivated in the surrounding districts; but they had arrived at no very definite conclusions on the subject when the work was handed over to the Agricultural Department in 1910.

The experiments were continued with seed of six Upland and two native varieties handed over by the Association; the Upland varieties were: Georgia, Hawkins' Prolific, Nyasa-

land, Truitt's Big Boll, all derived from *G. mexicanum*; Jones' Improved (*G. mexicanum* × *hirsutum*), Upland (*G. hirsutum*). One of the native cottons, Ishan, is a naked-seeded cotton derived from *G. vitifolium*, and Meko, the other, is a woolly-seeded cotton derived from *G. peruvianum*. To these were added seed of the long staple Upland varieties Allen (*G. hirsutum*) and Griffin (*G. hirsutum*, var. *religiosus*).

After the experiments had been continued for five years, the average yield of lint per acre and the average ginning percentage of lint of each variety for this period were recorded as follows :

Variety.	Average Yield of Lint per Acre.	Average Ginning Per- centage of Lint.
	lb.	
Georgia	125.8	30.95
Upland	119.9	30.74
Hawkins' Prolific	116.8	31.00
Ishan	112.2	29.87
Truitt's Big Boll	102.3	31.81
Jones' Improved	95.2	30.71
Griffin	91.7	29.88
Meko	91.4	25.74
Nyasaland	91.3	28.68
Allen	88.2	26.77

Measured in terms of yield per acre, the results are rather disappointing, still the quality of the cotton was so high that a representative collection of samples, which was entered for competition at the International Cotton, Fibres, and Tropical Products Exhibition, held in London in June-July 1914, was awarded the Silver Trophy presented by the B.C.G.A. for "the best general exhibit of various varieties of cotton shown by any Government Department of Agriculture of any British Colony or Protectorate, or of Egypt, or the Anglo-Egyptian Sudan."

Samples of the cotton of each variety were examined by commercial experts, and from a consideration of their report, in conjunction with the results of the cultural tests, it was decided to conduct further tests with the varieties Georgia and Upland, and to reject all the other varieties.

The selection of Upland cotton in preference to any of the native cottons was largely influenced by the following

circumstances. All the native cottons were affected by an extraordinary leaf-curl disease. The leaves of plants affected with this disease assume a peculiarly crumpled appearance ; they are undersized and frequently chloritic and mottled. The stems and petioles become distorted, flower and fruit production is diminished, and in certain cases the plants are sterile. The disease appears to be of a constitutional nature, for no fungus, insect, or other causative organism has been discovered to be associated with it. Upland cotton crops earlier and is more readily picked, because the bolls open wider ; it requires a shorter growing season, for native cotton is planted in mid-June and Upland cotton in mid-July. It is thus more economical of labour, and as it occupies the ground for a shorter period, it permits of a second crop being raised on the same ground in the one year. Moreover, the native cottons have a lower ginning out-turn, rarely exceeding 27-28 per cent of lint ; the lint is usually shorter, rough, and harsh, and is often khaki-tinted.

Eventually the variety Upland was also rejected, and steps were taken to improve the Georgia variety by selection. Georgia is a good medium staple cotton, white and strong, and is considered by commercial experts to be well adapted to Lancashire's requirements. Favourable progress was made with the work of selection, for in 1918 the average yield of lint per acre, on $41\frac{1}{2}$ acres, had risen to 211 lb., and the average ginning percentage of lint to 32.4. In the following year a similar area yielded an average of 662 lb. of seed cotton per acre, an average yield of lint of 200.4 lb. per acre ; the highest and lowest yields of seed cotton per acre being 930 lb. and 450 lb. respectively.

Moor Plantation is situated in the Oyo Province, which is the principal cotton growing area in the Southern Provinces, and in 1921 produced 19,000 bales of cotton. A commencement was therefore made to substitute the Georgia cotton for the mixture of native cottons generally grown in this Province. Unfortunately the depletion of the Agricultural staff, brought about by the War, seriously interfered with this project, and little progress was made.

The results of the distribution of the Georgia cotton was not considered satisfactory, and its cultivation was abandoned. In 1921, 675 tons of Allen cotton seed were imported

from the Northern Provinces for distribution in the Oyo Province. It is to be observed that, although Allen cotton originally gave less favourable results than Georgia cotton at Moor Plantation, and that when it was re-tested there in 1921, 24 acres only yielded an average of 55 lb. of lint per acre, it is the variety that has been selected for general cultivation in the Northern Provinces. As the soil and climatic conditions that prevail in the Northern Provinces and in the Oyo Provinces are very different, it is not surprising that the distribution of Allen cotton in the Oyo Province was a failure. The Agricultural Report for 1922 states: "With some hesitation and reluctance, it was decided that we must practically go back fifteen years and start to study from the beginning the whole question as to whether and how a cotton, really fit for export, can be grown in the Southern Provinces." It only requires a slight experience of the mentality of the conservative native farmer to be able to appreciate the deplorable effect on the cotton industry which is likely to be produced by this change of policy.

Maigana Farm.—This farm is situated near Zaria, in the Northern Provinces. Since 1913, experimental work has been mainly devoted to manurial and other cultural tests with various cottons, and to the improvement of Allen cotton by selection. A four-course system has been in operation, *i.e.* (1) cotton, (2) Guinea corn, millet, and cow-peas, (3) cotton, and (4) ground-nuts. Generally the yields recorded have been lower even than those obtained at Moor Plantation up to 1919.

In 1914, the average yield from all the varieties, on 40 acres, was 369 lb. of seed cotton per acre. Allen yielded an average of 493 lb. of seed cotton per acre; one acre, which received an application of artificial fertiliser in 1913 and 3 tons of cattle manure in 1914, yielded at the rate of 675 lb. of seed cotton per acre. Georgia cotton was tested for the first time, and yielded at the rate of 369 lb. of seed cotton per acre.

In 1915, the average yield for all varieties, on 40 acres, was 364 lb. of seed cotton per acre. Allen yielded at the rate of 360 lb. of seed cotton per acre, while Georgia yielded at the rate of 450 lb. of seed cotton per acre.

In 1919 and 1920, the average yield of seed cotton per acre for the whole farm was 457 and 347 lb. respectively.

Recently it has been reported that selected strains of Allen cotton have yielded over 900 lb. of seed cotton per acre, while individual plants have produced lint up to $1\frac{1}{2}$ inch in length, as against $1\frac{1}{8}$ inch for the Allen cotton generally grown.

In 1919 and 1920, the cost of cotton production on this farm amounted to £2 : 4 : 5 and £3 : 6s. per acre respectively. The value of the seed cotton produced was rated at $3\frac{3}{4}$ d. and $4\frac{1}{2}$ d. per lb. respectively in the two years mentioned, and the profits earned were estimated at £4 : 19 : 1 and £3 : 4 : 3 per acre.

Distribution of Allen seed to growers commenced with 2 tons in 1914, followed by 7 tons in the succeeding year ; the quantity of seed distributed increased yearly until in 1923 it reached 1911 tons. The production of Allen cotton year by year has been as follows :

Season.	Bales of 400 lb.	Price per lb. of Seed Cotton locally.	Season.	Bales of 400 lb.	Price per lb. of Seed Cotton locally.
1915-16	121	$1\frac{3}{4}$ d.	1920-21	5,405	$4\frac{1}{2}$ d.
1916-17	433	$1\frac{3}{4}$ d.	1921-22	10,050	2d.
1917-18	855	$2\frac{1}{4}$ d.	1922-23	10,500	2d. to $2\frac{1}{2}$ d.
1918-19	2,248	$2\frac{3}{4}$ d.	1924	15,690	$3\frac{1}{2}$ d. to 4d.
1919-20	3,568	$3\frac{1}{4}$ d.			

Pests and Diseases.—*Dysdercus* cotton stainers are the most serious insect pests of cotton, and it has recently been reported that they are the principal cause of the comparatively low yields that are obtained in the Southern Provinces. During the course of experiments, when stainers were fed in cages, it was ascertained that, out of the numerous plants on whose seeds the insects feed, there are only three on which they can grow to maturity and breed ; these are cotton, okro (*Hibiscus esculentus*, Linn.), and the wild silk-cotton tree (*Eriodendron anfractuosum*, D.C.). A “close” season for cotton and okro is therefore under consideration, but it is thought that the matter of dealing with the large number of silk-cotton trees that exist is too big an undertaking.

Other common insect pests are the Sudan red boll-worm, the American boll-worm, and the *Earias biplaga* boll-worm,

aphis, caterpillars, and grasshoppers. Fortunately shifting cultivation and mixed cropping tend to keep all these pests in check to a certain extent.

Fungoid diseases that cause a certain amount of trouble are Anthracnose, Rust, Areolate Mildew, and a leaf-vein disease attributed to a *Colletotrichum*.

The peculiar leaf-curl disease has already been referred to.

At the Government farm near Ilorin, bud and boll shedding has seriously affected crop yields. This phenomenon was most acute during wet periods, and it is suggested that it is attributable to the high atmospheric humidity and the small amount of sunshine that obtains at such times, for when dry weather intervenes the rate of shedding is greatly reduced.

Handling and Marketing the Crop.—The success so far attained in developing the cotton growing industry is largely attributable to the work of the B.C.G.A. ; for the export of cotton has been made practicable by their excellent arrangements for buying, ginning, and marketing the crop, and, most important of all, by their guaranteeing the grower, in advance of the harvest, a reasonable price for his crop. This procedure has on several occasions involved the Association in serious losses through an unexpected fall in the market price of cotton. Mention has already been made of their activities in providing expert cotton growers to start experimental plantations and to give advice to the native growers. From the outset the B.C.G.A. has supplied, free of charge, all seed required for planting purposes, and for several years undertook its distribution as well, but of late years Government has borne the expense of packing and transport.

In addition to their four principal ginneries, which are situated at Lafenwa, Ibadan, Oshogbo, and Zaria, all on the Lagos—Kano Railway and about 60 miles distant from each other, and one at Lokoja, several pioneer ginneries were erected at various centres. The latter were, however, closed down when it was found that the production of cotton, in the districts which they were erected to serve, showed no prospect of increasing to a sufficient quantity to justify their maintenance. Owing to the extension of Allen cotton cultivation in the north, it has been decided to remove the ginnery from Lafenwa to the Zaria Province, and a second small power ginnery from Eruwa to the Sokoto Province.

The available ginning facilities are sufficient for handling 45,000 to 50,000 bales per annum, and there is ample storage accommodation for seed cotton and bales at all the ginneries.

The Association has always rendered the Agricultural Department every possible assistance in their efforts to introduce improved varieties of cotton, and has paid increased prices for such cotton with the view to encourage the farmers to grow them more extensively.

The standard type of B.C.G.A. ginnery comprises two batteries of 4 gins, with 70 saws to each gin. The seed cotton is automatically conveyed by pneumatic feed to the gins, and there are also conveyers for the seed and lint. The hydraulic press turns out 8 bales per hour. The weight of the bales is regulated by an electric attachment, so that each bale contains almost exactly 400 lb. of lint. They have a density of 28 lb. per cubic foot, or 80 cubic feet to the ton weight, and measure 3' 4" $\times$ 2' 1" $\times$ 1' 9". The bales are well covered by stout canvas, and arrive on the market a model of neatness that might well be copied with advantage by exporters in many other countries. The system of handling dispenses with the slashing of the bales for sampling purposes, which mutilates American cotton bales.

The seed is conveyed from the gins to hoppers, where it is automatically weighed as it is sacked.

The ginnery motive power is provided by gas engines of 200 h.p., the gas being made from the cotton seed. Each ginnery is protected against fire by automatic sprinklers.

A small experimental oil mill was erected at the Ibadan ginnery, but as little local demand exists for the cake or the oil, it has been found most economical to ship the surplus seed to Europe and the oil mill has been dismantled. An inexpensive apparatus has recently been devised for pressing cotton seed into a much smaller space, the seed being made up into bales of 40 cubic feet to the ton. It was anticipated that much economy of space would be effected, with a consequent reduction of freight charges, and an endeavour was made to encourage the use of this apparatus in connection with the export of Nigerian cotton seed. Unfortunately the apparatus, consisting of a large iron box of a special type, which was sent up to Zaria for use in the cotton press, could not be used at the same time that the cotton was being

pressed, and when the ginning season ended the presses had to be thoroughly overhauled in readiness for the following season. It is therefore considered that a special full-power press is necessary for the purpose in view.

Until recently the ginning and marketing of the crop was entirely carried out by the B.C.G.A. The price guaranteed by the Association was payable for seed cotton delivered at the ginneries or at any of the merchants' buying stores. Under an agreement with the Association, the merchants bought the cotton on behalf of the Association, forwarded it to the nearest ginnery, and received an agreed sum as a bonus for each pound of cotton that they handled. A great deal of the crop has, however, always been purchased from the farmers by native middlemen, who in turn sell it to the B.C.G.A. or the merchants; obviously this procedure absorbs profits which should accrue to the growers.

In 1923, the B.C.G.A. decided to terminate the agreement with the merchants, which had been in force for fourteen years, and to throw the buying open to all, but to undertake the ginning and baling of cotton for buyers at a reasonable price.

Hitherto one price was paid for all grades of cotton, except for that produced from selected seed distributed by the Agricultural Department. Much adulteration took place, and little care was taken to keep the cotton clean. A system of grading has now been introduced so as to encourage cleaner picking of the crop and better care of it afterwards, as well as the elimination of immature and stained cotton. Three grades are recognised: these are N.A. 1, N.A. 2, and N.A. 3 for the American variety, and N.N. 2 and N.N. 3 for the native types, and appreciably higher prices are offered for the higher grades. Inspectors have been appointed to attend all the cotton markets to supervise the grading.

Summary.—The possibilities for development are enormous, provided that additional transport facilities are supplied, for Nigeria possesses vast areas of land well adapted to cotton cultivation; many of these areas are densely populated, and the people are for the most part intelligent, law-abiding farmers, while the seaports are nearer to Liverpool than those of any other cotton-growing country in the Empire. Yet while Uganda produces a bale per 23 head of

population, Nigeria only produces a bale per 781 head of population.

Unfortunately, so long as the size and quality of the crop is dependent on the date of arrival, the quantity and distribution of the rains, a short crop must be looked for whenever one of these factors fails. Irrigable land there is in abundance in the vicinity of the Niger, Benue, Kaduna, and other rivers. It is gratifying to observe that the Government has appointed an irrigation engineer to investigate and report on the question of irrigation, for it is probably by this means that the extensive development of Nigeria's cotton industry will be best attained.

In the Northern Provinces the only competing crop of any importance is ground-nuts, which is, of course, an admirable rotation crop with cotton. In the moist forest zone of the Southern Provinces, cotton is unlikely to make much headway against such valuable and lucrative crops as cocoa, palm oil and kernels, and cola ; but outside the forest belt there are enormous areas of valuable cotton land where such competition does not exist.

It is, however, of prime importance that every possible effort should be devoted to increasing the yield and the quality of the crop and by this means enhance the profits to the producer.

NIGERIA'S COTTON PRODUCTION

(Bales of 400 lb.)

Note.—The cotton used in the local weaving industry is not included in these figures.

Year.	Crop.	Year.	Crop.	Year.	Crop.
1903	700	1911	6,200	1918	4,900
1904	2,900	1912	11,400	1919	17,200
1905	3,800	1913	16,100	1920	17,200
1906	7,400	1914	14,400	1921	31,200
1907	10,700	1915	7,100	1922	15,000
1908	6,000	1916	19,400	1923	16,800
1909	12,700	1917	12,500	1924	24,000
1910	6,400				

GOLD COAST

The Gold Coast Colony with its dependencies Ashanti and Northern Territories, and the mandated territory of Togoland, comprise an area of 82,000 square miles. It is situated in the Gulf of Guinea; on the north and west it is bounded by the French Sudan and Ivory Coast, and on the east by Dahomey. It has a population of more than $1\frac{1}{2}$ millions, of whom only about 1000 are Europeans.

The climate is humid, more especially in the vicinity of the dense vegetation of the coastal belt, but generally the rainfall is not excessive considering the geographical position, for it is nowhere in excess of 100 inches, while that of Accra, the capital, is similar to that of England, *i.e.* 24·36 inches.

Extending from the coast for about 200 miles inland is a belt of forest and dense undergrowth; next to this is a belt of more shrubby vegetation, while still further inland is found low bush and grass or park-like country.

The soil and climate are generally well adapted for cotton production, but in the moist zone more lucrative crops, such as cocoa, can be grown with less labour. The varieties of cotton favoured by the natives are forms of *G. peruvianum*, *G. vitifolium*, and *G. brasiliense*. The cultural methods employed are similar to those already described in Nigeria.

During the last twenty-five years the Government and the B.C.G.A. have made persistent efforts to encourage the development of cotton growing. Large quantities of seeds of various cottons have been distributed at different times. Cultural experiments have been conducted in the Krepi country on the east of the Volta River, at Tamele in the Northern Territories, and elsewhere. In 1905 the undermentioned yields were recorded at the Labolabo experiment farm in the Krepi country:

Kind of Cotton	Native.	Upland.	Affi.
Yield of seed cotton per acre (lb.)	369	450-730	215

It was satisfactorily demonstrated that good crops of cotton of excellent quality can be produced, but it remains to be proved which varieties can be most profitably cultivated.

The B.C.G.A. maintained buying and ginning stations at Labolabo; but in 1915 it was decided to close down operations

in the Northern Territories, and in 1916 the ginnery at Labo-labo was disposed of. There was keen competition from cocoa, Gold Coast being the largest cocoa-growing country in the world. Furthermore, transport for cotton is rather difficult, for although the Volta River is available, many rocks in the river-bed cause rapids, so that only canoe transport is possible.

With improved transport facilities it seems probable that the industry could be successfully developed in the regions outside the forest belt, which are unadapted for the cultivation of cocoa and other more lucrative and moisture-loving crops. In the colony the prevalence of tsetse-fly restricts the use of cattle and horses to a few isolated districts. There are few serviceable waterways, while roads suited to vehicular traffic are for the most part confined to the more developed portions of the country. Conditions better suited for cotton production prevail in the Northern Territories, where labour is cheap, and horses and cattle are available for transport and agricultural operations ; but the greatest obstacle is transport, for the nearest point of these territories to the sea is 200 miles distant. Part of this distance is, however, covered by a railway which runs from the coast to Kumasi, 168 miles.

The export of cotton from Gold Coast since 1900 has been as follows :

Year.	Exports (Bales of 400 lb.).	Year.	Exports (Bales of 400 lb.).	Year.	Exports (Bales of 400 lb.).
1900	52	1908	129	1916	45
1901	7	1909	78	1917	110
1902	..	1910	29	1918	53
1903	26	1911	24	1919	..
1904	144	1912	51	1920	63
1905	73	1913	69	1921	48
1906	232	1914	58	1922	15
1907	140	1915	30	1923	790

TOGOLAND (mandated Territory).—The Germans turned their attention to cotton production in Togoland at the end of the nineteenth century, and American cotton experts were engaged to assist in developing the industry. Experiment farms were laid out at various centres, and an agricultural

school was established for the training of native students. After their period of training expired the students were sent back to their homes and were given grants of land for the purpose of cotton growing. Eight ginneries were established in different districts.

Various kinds of cotton were experimented with, and eventually it was concluded that the most suitable kinds of cotton to grow in the different districts were native Sea Island in the south, Upland in the central zone, and an East Indian variety in the north. The exports of cotton from 1902 to 1913 were as follows :

Season.	Exports (Bales of 550 lb.).	Season.	Exports (Bales of 550 lb.).	Season.	Exports (Bales of 550 lb.).
1902	80	1906-7	1205	1911	2071
1903	128	1907-8	1691	1912	2209
1904-5	519	1908-9	2300	1913	1893
1905-6	857	1910	1559		

Although much of the territory where this cotton was grown has been ceded to the French, of that ceded to Great Britain, along with the British territory in proximity to the left bank of the Volta River eastward to Togoland, and on the right bank east and south of Akuse, there appears to be upwards of 100 square miles of land suitable for cotton production, and Government is instituting investigations with the object of encouraging its cultivation.

Investigations are likewise proceeding as to the possibility of utilising the water of the Volta River for a scheme of irrigation in this region.

SIERRA LEONE

Sierra Leone is bounded on the east by Liberia, and on the north and west by French Guinea ; it comprises an area of 34,000 square miles and has a population of $1\frac{3}{4}$ millions, of whom less than 1000 are Europeans.

Commencing in 1901, the B.C.G.A. made strenuous efforts to develop the cotton-growing industry. American cotton experts were engaged to carry out experiments and to instruct

the natives. In 1905 they laid out a farm of 1000 acres with various kinds of cotton at Moyamba in the Protectorate. A native variety known as Kwandi (*G. punctatum*), which produces a pale cream-coloured lint with a staple of 1 inch, gave the best results. Serious difficulties were, however, encountered, especially with regard to the heavy rainfall and the apathy of the natives, and in 1907 they abandoned the enterprise.

It is considered that other parts of the country than those in which the Association operated offer better prospects, and the Government has taken the matter up again. Unfortunately, in the new areas chosen for development transport facilities are almost entirely absent, and success will probably depend to a large extent on the provision of an adequate transport service. Five tons of seed of Allen cotton were imported from Nigeria, and samples of cotton grown from it have recently been valued at 17·70d. per lb., on a basis of October 1925 "American futures" at 14·20d. per lb. The cotton is described as of good colour, clean, $1\frac{3}{8}$ inch staple, and fairly strong. A small ginnery presented by the B.C.G.A. has recently been erected at Boia to deal with the crop.

EXPORTS OF COTTON FROM SIERRA LEONE

Year.	Bales of 400 lb.	Year.	Bales of 400 lb.	Year.	Bales of 400 lb.
1903	3	1905	172	1907	33
1904	71	1906	220	1908	1

GAMBIA

Gambia consists of a narrow strip of land which follows the course of the Gambia River for a distance of 250 miles. It has an area of 4130 square miles, while its population is about 150,000.

The Mandingo tribe grows cotton for their native looms which compares favourably with "Middling American", but is less white and silky. The Jolah tribe grows a short-stapled woolly cotton which is whiter than that grown by the Mandingos.

Efforts have been made from time to time to develop the cotton-growing industry, but with little success, primarily owing to the preference shown by the natives for the cultivation of ground-nuts, which constitutes the staple industry of the colony. In 1843, 174 bales of 400 lb. each of cotton were exported. In 1862 a ton of Egyptian cotton seed was distributed, from which 263 bales of cotton were produced. Egyptian cotton was reintroduced in 1890 and it again gave good results.

In 1902, at the instigation of the B.C.G.A., seed of various American and Egyptian varieties was distributed, an American cotton planter was engaged to carry out investigations, and an experiment farm was established to test both native and exotic varieties. Government arranged for the purchase of all cotton grown from imported seed. The enterprise was, however, abandoned in 1905, for the natives found that they could dispose of their crops more lucratively for local manufacture; and, moreover, cotton could not compete successfully with the more favoured ground-nut.

As many parts of the country are well adapted to cotton cultivation, and as the vicinity of the Gambia River affords a ready means of transport, attempts are again being made to develop the industry. It seems possible that the use of this river for irrigation purposes would be of material assistance in this connection.

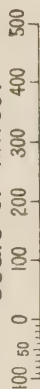
EXPORTS OF COTTON FROM GAMBIA

Year.	Bales of 500 lb.
1903	27
1904	125
1905	153

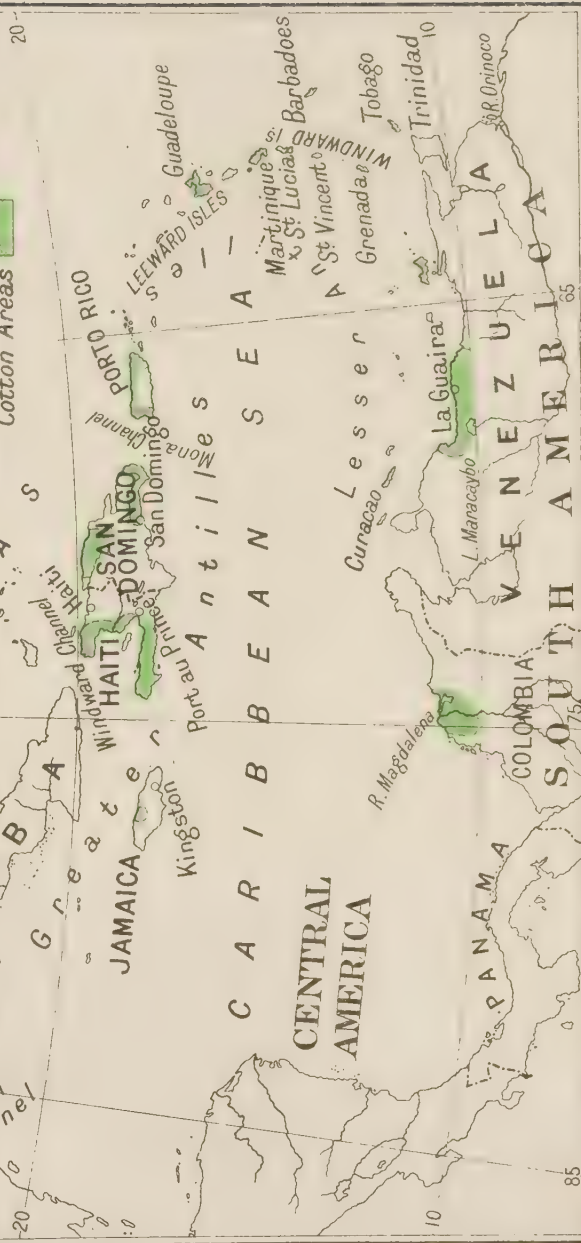
WEST INDIES

The British West Indian Islands comprise an area of 12,300 square miles, and have a population of 1,730,000. Included in this group of islands are: Jamaica, St. Lucia, Bahamas, St. Vincent, Barbados, Grenada, Trinidad, Tobago, and the Leeward Islands—which consist of Antigua, St. Kitts,

Scale of Miles.



Cotton Areas



Montserrat, and the Virgin Islands—all of which grow cotton to a greater or less extent.

The Cotton Industry.—Cotton was extensively cultivated in the West Indies in the eighteenth century, and during the period 1786–90 they produced about 70 per cent of the world's commercial supply of this staple. In 1792 the finest cotton that had ever been brought to England was received from Tobago. Yarn was spun from it at the rate of 278 hanks to the lb., and sold for 20 guineas a lb. It was one of the staple crops of the early colonists, and as early as 1801 25,000 bales of cotton were exported to Europe.

Although Sea Island cotton has been grown in the West Indies for 150 years, it is not indigenous, but is probably a culturally improved hybrid of *G. vitifolium* or *G. barbadense* with *G. brasiliense*. Records show that cotton seed was sent from the Bahamas to Georgia in 1785; and there is little doubt that a superior quality of cotton, closely allied to, if not identical with, what is known as Sea Island to-day, was grown in the West Indies long before it was grown in the United States.

In course of time cotton cultivation in the West Indies declined in favour of sugar, but the cultivation of long-staple cotton was never altogether abandoned. Increased areas were grown during the American Civil War. Subsequently its cultivation was more or less confined to the Grenadines, where a coarse perennial cotton known as Marie Galante was favoured, of which the best varieties have a staple of $1\frac{3}{16}$ to $1\frac{5}{16}$ inch.

The revival of fine Sea Island cotton cultivation began in 1901, when small experimental plantings were made with seed obtained from the United States. Two years later the Imperial Department of Agriculture introduced seed of the best River's type of Sea Island cotton from the seaboard of South Carolina. The quality of this cotton has been maintained, and even improved, by careful selection, so that to-day the finest and strongest cotton in the world is produced in certain of these islands. Owing to the destruction of the American Sea Island cotton industry by the boll-weevil, the West Indies are now practically the sole source of supply of this valuable staple. The record crop of all grades was harvested in 1911, when 7560 bales were produced.

Owing to its fineness and length of staple, Sea Island cotton is in demand for lace making and for the manufacture of the finest cotton fabrics. But trade depression has curtailed the demand to such an extent that the crops have not been consumed, and the consequent fall in prices has caused considerable discouragement to the growers. Their difficulties have been still further increased by the appearance in 1920 of the pink boll-worm. Fortunately prompt measures have been taken by the local authorities to deal with the pest, by establishing close cotton seasons and by disinfecting the seed, so that damage to the crop has been considerably modified. Consideration is now being given to the matter of breeding long-stapled varieties of cotton, which would find a less specialised demand than Sea Island cotton.

The E.C.G.C. have established an experiment station in St. Vincent for the study of problems connected with the genetics of cotton and the production of improved strains.

Cotton is a rain-grown crop throughout the islands, and it is grown both as an estate's crop and also by small peasant proprietors. On estates it is grown as a main crop and also as a rotation or intermediate crop with sugar-cane. It is apparently immune to the pernicious sugar-cane root disease, which dies out for lack of a suitable host when the land is placed under cotton.

Although wages are low as compared with those of cotton-growing countries, such as the United States and Australia, the labour supply is not abundant.

The Government and the B.C.G.A. have done much to foster the industry by means of grants and loans in aid of the purchase and erection of machinery for handling the crop, advances on easy terms to prospective growers, skilled advice and assistance on matters pertaining to the treatment and handling of the crop, and the provision of a ready means of marketing the produce.

The islands of St. Vincent, St. Kitts, Barbados, and Montserrat are the principal exporters of Sea Island cotton; the first named producing the most and best, though it is closely followed by St. Kitts.

The best St. Vincent and St. Kitts staples, besides being exceptionally strong, fine, lustrous, and uniform, have a length of 2 inches and over. The staple of "Ordinary Fine" West

Indian Sea Island cotton ranges from $1\frac{3}{4}$ to 2 inches. St. Vincent cotton has been spun into yarn of 400 "counts", which gives a length of yarn of 190 miles to the lb. The usual "counts" of West Indian cotton range from 160's to 400's.

Cotton produced in the Various Islands.—The extent of the industry in the different islands is shown in the table given below.

WEST INDIAN COTTON PRODUCTION

(Bales of 400 lb.)

WEST INDIES

Year.	St. Vincent.	Barbados.	St. Lucia.	Bahamas.	Jamaica.	Grenada.	Trinidad and Tobago.
1912	1200	1070	10	30	90	950	30
1913	1210	1110	10	30	170	1000	20
1914	1090	610	10	..	80	900	..
1915	920	760	10	50	110	920	..
1916	710	340	..	20	40	970	20
1917	520	160	..	10	..	690	..
1918	1730	290	..	10	..	600	..
1919	2050	250	10	40	10	770	..
1920	560	220	10	20	..	940	120
1921	750	440	10	..	..	820	..
1922	1440	1080	10	30	10	640	..
1923	1210	..	10	10	..	830	..

LEEWARD ISLANDS

Year.	St. Kitts.	Montserrat.	Antigua.	Virgin Islands.
1912	1530	880	250	120
1913	1640	730	460	90
1914	1840	730	470	80
1915	1840	950	240	90
1916	700	700	200	70
1917	890	780	90	40
1918	1030	1000	160	50
1919	1610	1100	720	70
1920	1410	1370	110	120
1921	1940	990	290	120
1922	880	920	80	20
1923	1060	1160	160	..
1924	1560	1210	..	..

Pests and Diseases.—In addition to the pink boll-worm a cotton stainer (*Dysdercus Andreae*), the cotton worm (*Alabama*

argillacea), the flower-bud maggot (*Contarinia gossypii*), and the leaf-blister mite (*Eriophyes gossypii*) cause a considerable amount of damage to the crop in certain seasons. Although progress has been made in the breeding of strains of cotton resistant to diseases, Angular Leaf Spot, Anthracnose, Boll Rot, and Mildew are still troublesome.

Cotton Cultivation and Marketing.—The conditions under which cotton is produced in the various islands necessarily vary to a certain extent, but those prevailing in St. Vincent may be taken as typical, at any rate as far as Sea Island cotton is concerned.

St. Vincent comprises an area of 150 square miles. Throughout its entire length is a central backbone of mountains, with a large number of radiating valleys. As the lands slope from the mountains to the sea, drainage is good; but cotton can only be successfully grown on lands at fairly low elevation near the coast. The soil is a dark sandy loam, of volcanic origin, with a compact subsoil.

The rainfall is ample and sometimes excessive; the climate is moist and tropical. The average mean monthly rainfall, from June to November inclusive, ranges from 12·27 to 18·13 inches.

As soon as the rainy season sets in and permits the land to be worked, it is weeded. The ground is then ploughed or forked; ridges are thrown up with the plough, fork, or hoe, and weeds and manure are completely covered in the ridge. When cotton follows cotton, the weeds and manure are ranged in the furrows and are covered up by splitting the old ridges over them. The distance between the ridges varies from 4 to 5 feet apart. Sometimes the subsoil plough is used previous to ridging so as to ensure deeper tillage.

Artificial fertilisers are used to augment the limited supply of pen and other organic fertilisers and the use of cotton-seed meal is receiving increased attention. Many cotton lands have been largely depleted of potash and organic matter. The lack of potash is evidenced by the appearance of Rust and Red-leaf diseases. Experiments have fully demonstrated the deficiency of potash, for its application almost invariably produces an increased crop of as much as 76 per cent over unmanured plots. It was found that the application of phosphate is not advisable, since its use with potash is

less beneficial than potash alone ; moreover, that cotton-seed meal is not an economical fertiliser, unless it is supplemented with potash and pen manure ; and that artificial fertilisers and cotton-seed meal used in conjunction gave better results than either alone. It is found that when cotton is grown on the same land for several successive years, which is a common practice, the crop markedly responds to both artificial and organic fertilisers.

The seed is sown by hand in moist soil, usually in June, but the time of sowing is governed by the arrival of the rains. Four or five seeds are sown in each hole, the holes being 20 to 24 inches apart.

When the seedlings are 4 or 5 inches high the weakly plants are pulled up, leaving the two strongest at each stand ; three or four weeks later the weaker plant is eradicated. In order to protect them from the wind the plants are moulded up when they are 8 inches high, and again when they are from 12 to 15 inches high. Shallow interculture is carried out at frequent intervals until the bolls begin to open in October.

The bolls may continue to open till February or even March. The crop is chiefly obtained from the secondary branches, which constitute the first pickings, and is the best. Later pickings are produced by basal laterals and tertiary branches.

The crop is picked into canvas bags, 18 to 20 inches long and 18 inches wide, which are tied round the waist, thus leaving both hands free. Attached in front of the bag, and about one-half its size, is a pocket. Clean cotton is put into the bag as it is picked, and inferior cotton is put into the pocket. Sheets are placed at the ends of the plant rows, on which the cotton is spread as it is picked ; in case of rain the sheet is folded over the cotton. When cotton is picked in a moist condition, which cannot be always avoided, it is sun dried on trays that can be run under cover.

After drying, the cotton is bulked in large bags or heaps for about six weeks, which is said to improve the quality of the lint. It is then cleaned and graded for the ginnery on flat basket trays or benches ; it is handled with care so as to avoid injury to the lint. Four grades are usually observed : 1st white, 2nd white, 1st stained, and 2nd stained. The 1st

white principally consists of the first pickings ; the 2nd white consists of the bulk of the later pickings ; the 1st stained consists of some white and some stained cotton ; and the 2nd stained is all discoloured cotton. The stained cotton comprises from 10 to 20 per cent of the crop ; but the percentage is influenced by the weather, for it is higher in wet than in dry seasons, though insect stainers are likewise an adverse factor in this connection.

Yields.—The average annual yield of lint per acre in St. Vincent for the five seasons 1909–10 to 1913–14 was 103 lb. ; in the eight succeeding seasons the average fell to 74 lb., but in 1922–23 it rose to 167 lb. A few estates in St. Vincent give an average yield of 200 lb. of lint per acre, but 150 lb. of lint per acre is generally considered a fair yield in a normal season.

The average annual yield of lint per acre in Antigua, Barbados, Grenada, Montserrat, and St. Kitts during the three seasons 1919–20 to 1921–22 was respectively 118 lb., 86 lb., 115 lb., 157 lb., and 136 lb. The low yields are attributed to : (1) Adverse climatic conditions causing bud and boll shedding, and the spread of diseases ; (2) damage by pests and diseases not due to unfavourable weather ; and (3) the low fertility of cotton lands. The last mentioned is considered to be the chief cause. Better care in soil management is needed, including the more extensive and intelligent use of fertilisers, crop rotation, and other means of soil restoration.

Ginning and Baling.—Macarthy roller gins are employed for ginning purposes, and these have to be maintained in perfect working order, otherwise injury to the lint is caused. Ordinary River's Sea Island cotton has a ginning out-turn of 26 per cent of lint, but superfine Sea Island has a ginning out-turn of only 22 per cent of lint. Besides giving a lower ginning out-turn, superfine Sea Island cotton is more troublesome to pick and handle ; from 180 to 200 bolls are required to yield a lb. of superfine seed cotton, whereas 140 to 160 bolls suffice to yield the same quantity of ordinary fine Sea Island cotton.

The size, shape, and weight of the bales vary considerably in different islands. In St. Vincent the lint is pressed by a single plunger press, worked by hand, into long cylindrical packages, measuring 7 feet by $2\frac{1}{2}$ feet and weighing about 360 lb. net.

In St. Vincent and the Virgin Islands the purchase of seed cotton from the small growers is an important feature of the Government ginneries, and also in other islands where the ginneries are privately owned. In most cases the seed cotton is bought outright, while in others a share of the profits is eventually returned to the producer. Under the St. Vincent profit-sharing purchase scheme, after being graded as mentioned above, the seed cotton is brought to the ginnery, and payment is made on account, according to a fixed scale of prices. When the lint and seed have been sold, ginning and other handling expenses are deducted from the sale price, and a bonus equal to 75 per cent of the net profit realised is distributed to the growers.

BRITISH GUIANA

In the early part of the nineteenth century cotton formed an important portion of the exports from British Guiana. In 1827, 16,000 bales were exported; then a steady decline took place until 1843, when only 24 bales were exported. Since that date attempts have been made from time to time to resuscitate the industry, but with little success. The competition of sugar and labour shortage are quoted as the cause of the industry's decline and the failure to revive it.

The cotton originally grown was a perennial tree cotton, *G. brasiliense*, which produced a short-staple lint resembling Peruvian cotton. The aborigines of the hinterland still grow this type of cotton and use the produce in the manufacture of hammocks and other domestic articles.

Experimental trials with different varieties have been made by the Agricultural Department, and it is reported that types of cotton suited to the local conditions have been produced by crossing Sea Island and Egyptian cotton with the native cotton.

If labour became more abundant, there would appear to be a possibility of reviving the industry. In this connection it is of interest to observe that it has been suggested that arrangements should be made for the immigration of labour from some of the overpopulated areas in India.

IRAQ, MESOPOTAMIA (Mandated Territory)

Great Agricultural Potentialities.—The British Mandatory sphere of Iraq comprises an area of 150,000 square miles. It has a population of 2,850,000, of whom a large number are more or less nomadic Arab cultivators and wandering tribes.

The climate is characterised by extreme heat in summer and a degree of cold in winter that is rarely experienced in other similar latitudes. The greatest heat prevails in July and August, when it ranges between 78° to 115° F., and the lowest in December and January, when it ranges between 37° to 62° F. The mean annual precipitation is only about 10 inches; but it is very variable, for in one year it has been known to rise to 22 inches and in another to fall to less than 2 inches. Agriculture is thus dependent on irrigation.

Mesopotamia, or the “River Country”, the traditional site of the Garden of Eden, derives its name from the fact that the Tigris and the Euphrates traverse the plain country by a devious course, with numerous tributaries and cross connections, and in some cases form enormous marshes.

It was the granary of the world for centuries. Cuneiform tablets of the Babylonian age, discovered in the Khabur Valley of Upper Iraq, record that the ancient wealth of the country was largely due to the production of cotton.

A vast irrigation system was gradually developed, eventually to be devastated by Genghiz Khan and his Mongol hordes, who destroyed the headworks of the canals and laid the country desolate. To-day the ancient canals and water-courses can still be traced, and it is considered that in many cases they can be cleared and utilised by the scientific use of water. Engineers of world-wide repute have appreciated the agricultural potentialities of the country, and gigantic schemes have been conceived by which 15 million acres might be brought under cultivation.

Soil and Effects of Salt.—The soil consists of a light calcareous loam, which contains a similar quantity of nitrogen as typical Egyptian soils, and potash and phosphoric acid in sufficient quantity for cotton cultivation.

In time of flood the Tigris and the Euphrates carry five times as much silt as the Nile, a circumstance that increases the cost of canal irrigation. The water contains a high per-

centage of salt as compared with the Nile ; large areas have thus become saturated with salt and consequently have been abandoned. This condition is most common in the areas nearer the sea, where the finer silt is deposited, but such areas could probably be reclaimed if a sufficient supply of fresh water were available for scouring purposes. Exceptionally fertile land, well adapted to cultivation and irrigation, is formed by the deposit of the coarser silt in the upper reaches.



It is considered that soil salinity is not only due to the actual salt evaporated from this water put on the land in recent years, but to the alteration of the level of the subsoil water and the bringing up of salt from below, which is caused by defective drainage. The drainage problem is thus quite as vital as irrigation.

Irrigation.—Sir William Willcocks, famed for his work in connection with Egyptian irrigation, was employed by the Turkish Government in 1910 to prepare a scheme for the reconstruction of the works on the Tigris and Euphrates, and the first part of the scheme was completed in 1913. An irrigation canal capable of irrigating 300,000 acres was opened in 1919.

It is estimated that there are about 300,000 acres on the banks of the Tigris and Euphrates that could be irrigated from these rivers by means of mechanical appliances. Above Baghdad, on the banks of the Diala, a tributary of the Tigris, there are 80,000 acres capable of canal irrigation, and about 120,000 acres on the Euphrates commanded by the Hindia barrage. It is considered that, if the necessary irrigation and other facilities were provided, one-third of this area could be cultivated with cotton each year by the existing population. It is further estimated that the damming of the Diala would provide sufficient water to bring $1\frac{1}{2}$ million acres under cultivation.

Transport.—Transport is more satisfactory than is the case in many of the new cotton-growing areas. There is a steamer service between Basra and beyond Baghdad on the Tigris, while barges and Arab craft ply both on the Tigris and the Euphrates. In addition there is the railway system built by the Turks—a meter gauge; and one built by the British—a standard gauge. These two systems were valued, at the termination of the late war, at 3 million pounds sterling, and are running at a profit, which is being used for improvements and extensions. There are also several branch lines. There is an abundance of camels and donkeys for use where mechanical transport would not pay, while there is the projected motor service between Beyrout and Baghdad, a distance of 650 miles.

The Cotton Industry.—The native cotton is allied to *G. herbaceum*, and produces lint comparable with “Middling” American cotton. The soil and climate are generally well adapted to its cultivation, but the development of the industry is restricted by the lack of irrigation, drainage and transport facilities, and in certain cases by the lack of population.

A deputation of the B.C.G.A. that visited Iraq in 1919 were favourably impressed with the country for cotton production. At present all the cotton is bought, ginned, and baled by the B.C.G.A., which has an up-to-date ginnery at Baghdad. The lint is pressed into 400 lb. bales with a density of 25 lb. per cubic foot. All the cotton is shipped to Liverpool. By looking after the distribution of the seed, and paying as high a price as possible for the seed cotton, the B.C.G.A. have

won the confidence of the farmers and may fairly claim credit for the progress so far made.

Under the more healthy and secure conditions of life that now prevail in the country, it is probable that the population will rapidly increase. If the necessary capital for development work is procured and a really sound irrigation system established, it is considered that cotton production will be enormously increased in the near future. The cotton-producing possibilities of the country have been recently estimated, perhaps optimistically, at 1 million bales per annum. Adequate water control and political tranquillity are the two factors most necessary for the industry's development.

Experimental Work.—Experimental planting was commenced by the Agricultural Department shortly after the Armistice, with the primary object of determining which variety is best suited for general cultivation. Unfortunately, unexpected disasters in the form of locusts, Arab risings, and water shortage have retarded progress. Altogether some 30 American, Egyptian, and Indian varieties have been tested.

The experiments have shown that the high temperatures that obtain during the summer months cause the water requirements of the crop to be higher than is the case in Egypt. That cotton is best planted before the end of March. Further, that Egyptian cotton can be grown equal to or even surpassing the quality of the average type grown in Egypt; while American cotton can be grown superior in quality to the average cotton crop of America.

The local conditions have been proved to be well adapted for the cultivation of the clover, which is such a valuable adjunct to cotton production in Egypt. In order to protect the cotton crop from the strong winds of July and August it has been found necessary to grow on the channel banks surrounding the plots a wind-break of castor oil plants. The average number of irrigations demanded by the crop is from twelve to fourteen; and the regular and timely application of water is emphasised as being vital to the successful cultivation of the crop. In 1922, when fourteen irrigations were given the experimental plots gave an average yield of 2110 lb. of seed cotton per acre.

The variety which was eventually selected for general

distribution amongst the growers originated with Webber 49, a long-stapled American variety, which since its introduction to Iraq has considerably altered its original character, and the name of Mesowhite has been given to it.

The 1923 crop amounted to 1100 400-lb. bales, while the 1924 crop was estimated at 2500 bales, all of this variety. As this is the only kind of seed distributed by the Agricultural Department, it should be possible to avoid the serious mistakes that have occurred in many other cotton-growing countries through the planting of mixed seed.

Planting takes place in March to April, and the crop is picked from August to November.

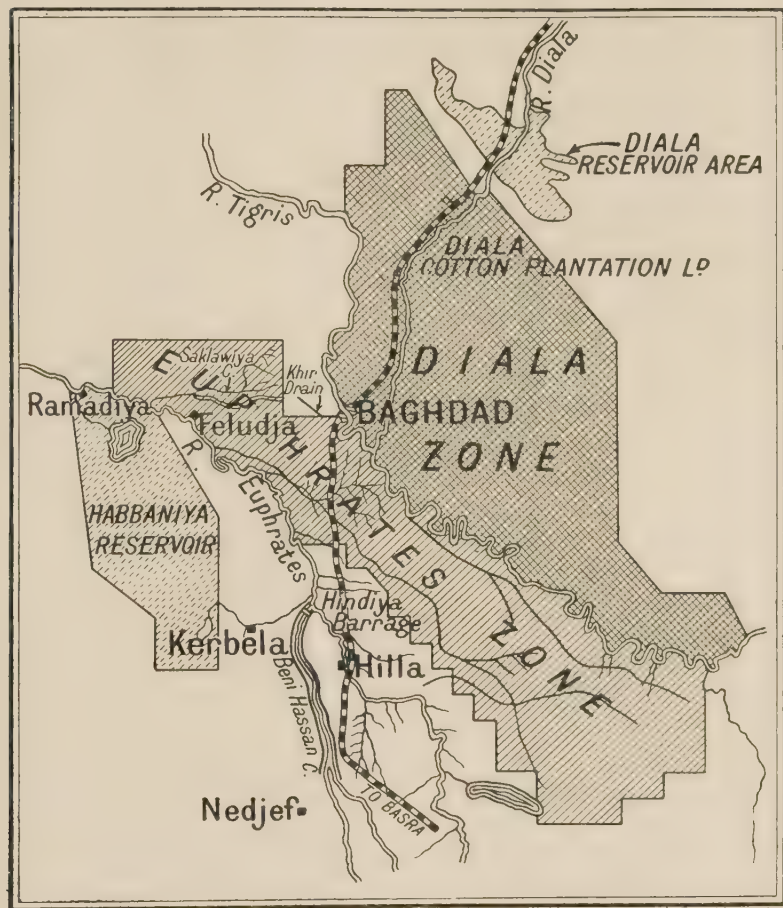
The severity of the spotted boll-worm attack has been the cause of much complaint, but investigations show that the apparent incidence of this pest is greatest where plants have suffered from water shortage or indifferent cultivation. *Platyedra vilella*, a new relative of the pink boll-worm, has recently been discovered feeding on young shoots and buds of the cotton plants, and has caused a certain amount of alarm. Locusts are also troublesome when the plants are young, and considerable areas often have to be replanted after a locust visitation. They are most prevalent in the north of the country, near the Mosul area, where grain is largely grown. The Agricultural Department is taking steps to check these depredations by destroying the eggs of the locusts. Experiments are being conducted with specially selected early varieties of cotton to test the possibility of sowing cotton after the depredations of the locusts have finished.

Impending Developments. — The extensive development of the cotton-producing potentialities of Iraq appear to be dependent upon the proper harnessing and distribution of the waters of the Rivers Euphrates and Diala. A company known as the Eastern Irrigations Ltd. has been formed for the purpose of developing large concessions of land granted to them by the Government, involving large irrigation schemes, both on the Diala and the Euphrates.

A subsidiary company, the Diala Cotton Plantations Ltd., anticipated a record crop this season (1925) from 600 acres. Existing native cultivators on their property receive 10 per cent of the crop, plus 1s. per day for $4\frac{1}{2}$ months of the year. Each cultivator has been allotted $4\frac{1}{2}$ acres. During 1925

the company received over a thousand applications for 150 allotments.

According to the *Financial Times* of March 4, 1925, the Iraq Government and the Norton-Griffiths Syndicate have



completed negotiations with reference to the irrigation works to be carried out by the syndicate in connection with cotton growing in Iraq. These works comprise : (1) At Felujah, on the Euphrates, a barrage and reservoir and the irrigation systems associated with these works ; (2) a weir on the Diala River and the attendant irrigation systems ; and (3) a dam

at Tawilah, on the Diala River, to form a reservoir of some 400 square miles, with water sufficient for the cultivation of 7,000,000 acres. It is estimated that the total cost of these works will amount to £17,000,000.

The political factor is, however, an important one, affecting not only cotton production, but the general economic development of the country as well. The form of government is that of an independent state in treaty relations with the British Government. Although the Arabs predominate, they are not united, and the Shiah and Sunnis, two of the most important sects, are bitterly opposed to each other. While the Jews and Christians consist of many nationalities.

The Cabinet has the assistance of British advisers, although until quite recently there were several vacant posts. In the case of a young country such as Iraq, where there is a lack of knowledge of government, the importance of appointing as advisers the best men it is possible to obtain cannot be too highly appreciated. This specially applies to the matter of finance, for unless the finances of the country are placed on a sound basis, outside capital will not be attracted for development purposes and progress will be hampered. It is therefore of interest to learn that the Colonial Office has appointed a Financial Commission to confer with the Iraq Government and to advise what measures should be adopted to balance the Iraq Budget.

The labour problem is also a difficult one, for although there is a population of nearly 3 millions, the bulk comprises nomad Arabs. Recently large numbers have settled on the land, and with good government the resident population should continue to increase. Suggestions have been made that labour should be imported from India and Egypt, but these are not considered feasible of adoption.

COTTON PRODUCTION IN IRAQ

(Bales of 400 lb.)

Year.	Crop.	Year.	Crop.	Year.	Crop.
1919	100	1921	210	1923	1500
1920	110	1922	350	1924	2500

CYPRUS

The Island of Cyprus, which is situated at the eastern end of the Mediterranean Sea, adjacent to Asia Minor, is in the form of a parallelogram, about 100 miles long by 30 to 60 miles broad ; but on the north the eastern extremity extends beyond this into a peninsula 40 miles long by 5 miles broad. The total area is 3584 square miles, and the population is three-quarters of a million. The rivers are chiefly mountain torrents and are dry from July to December. In the summer months, June to September, the climate is hot and dry, with a temperature ranging from 80° to 100° F., but slight frosts may occur in the winter. The average annual rainfall over the whole island is 20 inches, nearly all of which falls in the winter months.

Agriculture is the chief industry of the island. The cultivated area is approximately $1\frac{1}{4}$ million acres, and of this from 6000 to 10,000 acres are devoted to cotton. Of the uncultivated area, 450,000 acres are forest land and 320,000 acres are susceptible of cultivation. The small landowners cultivate their own lands, but the large ones do not ; there is thus a considerable number of leaseholders paying a fixed rent. The farmers are laborious, but their methods and appliances are primitive.

Cotton has been an important item in Cypriote agriculture since mediæval times, and as much as 2800 bales of 400 lb. each were annually exported during the fifteenth and sixteenth centuries. In 1871 the island's exports of cotton amounted to 1680 bales. To-day sufficient cotton is grown to export from 2240 to 2800 bales, and to provide raw material for the cotton fabrics that are woven locally in large quantities. In 1922 the exports of manufactured articles—domestic produce only—were valued at £12,000.

Native cotton (*G. herbaceum*) is grown on unirrigated lands, while American cotton is grown under irrigation. The colour of the native cotton is satisfactory, but it is harsh and short in staple. Efforts are being made by the Agricultural Department to replace the native cotton with American cotton ; in 1922, 700 tons of seed of American cotton were sown. Until the merchants offer better inducements to the growers to produce superior cotton, progress is likely to be

slow. At present the bulk of the exports find a ready market in Greece. Owing to the failure of the merchants to distinguish between the different varieties of cotton, the produce is of a very mixed character, and is unlikely to find favour in the English market.

Cotton is planted in May and June, and picking extends from September to December. The chief insect pests of cotton are the pink boll-worm, the Sudan boll-worm, and aphids.

Large areas of idle fertile land could be made to produce cotton if water were available during the summer months. Both along the coast and inland, supplies of subterranean water exist; at present the commonest system of raising water is by means of "Persian Wheels". The construction of large reservoirs to impound the surplus water of the Rivers Pedias and Ialias has only proved partially successful.

COTTON PRODUCTION IN CYPRUS

(Bales of 400 lb.)

Year.	Crop.	Year.	Crop.	Year.	Crop.
1902	1000	1910	3770	1918	1000
1903	890	1911	5450	1919	3330
1904	1100	1912	6050	1920	2690
1905	1610	1913	6040	1921	2550
1906	2960	1914	5410	1922	1510
1907	3800	1915	3640	1923	2230
1908	3300	1916	2500	1924	2180
1909	3030	1917	2060		

MALTA

Cotton was introduced and grown in Malta at the time of the establishment of the first Phœnician settlements; even at that remote period fabrics were manufactured from the lint, although they did not become renowned until the period of the Carthaginian rule. The excellence of Maltese fabrics prior to the Christian Era is testified by several ancient Latin scribes.

The spinning industry and cotton trade of Malta held a prominent position for many centuries. The development of the Egyptian cotton industry and later, owing to increased transport facilities, the American industry proved formidable

competitors. A revival of the industry occurred during the American Civil War, and larger areas were grown than at any previous period.

Two varieties of *G. herbaceum* are grown : one produces a white and the other a khaki-tinted lint. The white variety is more commonly grown ; the lint is uniform and lustrous but short, and is a lower grade than " Middling American ". American and Sea Island varieties have been introduced, but their cultivation is still in the experimental stage.

The farmers select their seed from the best bolls, but no proper system of breeding is practised. Fungus and insect pests cause little trouble. The seed is used as cattle food, and indeed it is imported for this purpose from the Levant, Smyrna, and Egypt.

Planting takes place at the end of April and the crop is harvested in September and October. The yield varies according to the season and soil conditions ; under optimum conditions a yield of 150 lb. of lint per acre is obtained. The quality of the lint is poor, and for the most part is unsuited for the Lancashire cotton industry.

The land available for cotton growing is limited, for the whole of the arable land is only about 42,000 acres, and this area has to sustain a population of 200,000 as well as 60,000 animals. All the irrigable land is utilised for the cultivation of more lucrative crops, whilst cotton suffers from the somewhat precarious rainfall. It is unlikely to be grown to any greater extent except in the adjoining island of Gozo.

COTTON PRODUCTION IN MALTA

(Bales of 400 lb.)

Year.	Crop.	Year.	Crop.	Year.	Crop.
1912	610	1917	320	1921	580
1913	560	1918	310	1922	1137
1914	490	1919	340	1923	1331
1915	460	1920	90	1924	348
1916	370				

CEYLON

A small quantity of cotton has been grown in Ceylon for many years, but the expansion of the industry has been

restricted by the cultivation of more profitable crops, such as rubber, tea, and cocoa. Moreover, in most of the areas where the latter crops are grown, the rainfall is too excessive for successful cotton production. Since the rise in cotton prices, however, energetic efforts have been made to develop a peasant cotton-growing industry in portions of the island where the competing crops mentioned above are not grown. These areas are mainly confined to the Manaar district in the north-west, and to the south-east and east of the island, portions of which are at present sparsely populated. Important railway extensions to the latter areas are under construction, which it is anticipated will serve to open them up for agricultural development.

Cotton-growing experiments have been conducted by the Agricultural Department at Ambalantota, in the south-east of the island, with various American, Egyptian, Sea Island, and Indian varieties. The experiments have given promising results, and the quality of the lint produced is satisfactory. Unfortunately the pink boll-worm has caused a certain amount of damage to the crop. The varieties selected for distribution to the peasantry are an American Upland type imported from South Africa, Durango, and Cambodia.

Planting takes place between September and November, and the crop is picked between February and April. In 1914 the B.C.G.A. had a ginnery at Colombo, which dealt with all the cotton that was then offering, but at the beginning of the War this was closed down.

A scheme has been adopted to encourage the peasants to grow one-acre plots of cotton on Crown lands, and in 1923 applications were received for seed to plant 1649 acres. The crop has been purchased by the Government at a guaranteed price, and eventually taken over by the Colombo Weaving and Spinning Mills. The Government is anxious to foster the industry in every way, and the E.C.G.C. has undertaken to provide the services of an expert to report on the cotton-growing possibilities of the country.

Although the areas available for cotton growing are relatively small, the low cost of living and the low price of labour may enable the cultivation of cotton to be extensively developed in the areas indicated above.

MALAYA

The early attempts to grow cotton in Malaya were not very promising, but recently the matter has been taken up by the Agricultural Department and more satisfactory results have been obtained. It is considered that long staple cotton of good average quality can be grown with a fair degree of success provided due attention is paid to the best time for sowing, cultivation, and control of pests.

The best prospects are shown in the eastern and northern States of the Peninsula, as these possess better defined wet and dry seasons, and lighter soil, than other portions of the country.

FIJI

Fiji comprises a group of about 250 islands of varying sizes ; Viti Levu, the largest, being over 4000 square miles in extent ; the second largest, Vanua Levu, being 2128 square miles in extent. The surface of the islands is generally mountainous. As regards climate, the two larger islands may be divided into two zones which vary in the degree of rainfall. The prevailing winds are the south-east trades, and a drier climate obtains on the leeward side of the islands ; this dry zone comprises about one-half the area of the two islands and it is this zone that appears to offer the best prospects for cotton production. The chief obstacle to extensive cotton production is lack of population ; the census of 1921 shows a total population of 157,266 persons, comprising 4000 Europeans, 85,000 Fijians, and 61,000 Indians.

At the time of the American Civil War, cotton was the chief article of export from Fiji. In 1870 and 1880, cotton to the value of £92,700 and £30,000 respectively was exported, and it was the second largest article of export. From this date increased attention was devoted to more profitable crops, such as copra and sugar, and the area planted with cotton gradually decreased, until in 1900 it practically ceased to be grown.

In 1906 experimental cotton planting was recommenced at the Lautoka experiment station, and Government endeavoured to foster the cultivation of cotton, especially among the East Indian settlers, but with little success. In

1920 attempts were again made to revive the industry. The total crop for 1922-23 and 1923-24 amounted to 85 and 157 400-lb. bales respectively ; it is practically all grown in the dry zone of Viti Levu.

Fiji is well suited for the cultivation of Sea Island cotton, and in the early days excellent crops of this type were produced. Planting is carried out from November to the end of January, and the crop is picked from June to October. There is an abundance of suitable land available, which can be acquired leasehold up to a period of forty years, with the right of renewal for a like term, at a rental of about 10s. per acre. The chief insect pests of cotton are the pink boll-worm, the *Earias fabia* boll-worm, *Dysdercus* cotton stainers and aphids.

The planters have recently evinced increased interest in the subject of cotton growing, and the E.C.G.C. despatched an expert to Fiji to report as to the possibility of re-establishing the industry, and his report states that the leeward side of Viti Levu and Vanua Levu is well suited to the cultivation of Sea Island cotton. The transport and handling of the crop are presenting serious difficulties. At present the greatest progress is likely to be secured by developing a system of small peasant farmers, and especially by encouraging Indian settlers in the drier regions which have been proved suitable for cotton. In addition it is considered that the Fijians may be encouraged to grow cotton on the communal system, provided they receive instruction in the use of the plough.

AUSTRALIA

Geography and Climate.—Australia is slightly larger than the United States of America, and some 1,150,000 square miles, or more than a third of it, lies within the tropics. Owing to its insular geographical position, and the absence of striking physical features, Australia is, on the whole, less subject to extreme weather conditions than are regions in similar latitudes in other parts of the world. The American cotton belt lies between 25° and 37° N. lat. ; the northern and southern limits of the Australian continent are the parallels of latitude 10° 4' S. and 39° 8' S.

Many parts of the country are unadapted for cotton cultivation owing to the scanty or unsuitably distributed rainfall that they receive ; still over 531,000 square miles of Australia receive from 20 to 30 inches of rain, 202,000 square miles receive 30 to 40 inches, and 190,000 square miles receive over 40 inches. Rainfall is most abundant on the coast, and chiefly in the eastern and northern portions, where also the atmosphere is most moist.

The primary limiting factor in cotton production is population, which only amounts to 6 millions, and 44 per cent of this is found in six large cities. Sydney alone has a population of over a million. The density of population is only 1·87 persons to the square mile ; Australia is thus the most sparsely populated of the civilised countries of the world.

The areas capable of producing cotton have not yet been accurately defined, but they are estimated to be as large as the American cotton belt. The most promising areas are to be found in Queensland, and it is in this State that most progress has been made. New South Wales is next in importance, while the Northern Territory, Western Australia, and the irrigation settlements in the south of the continent likewise possess considerable areas that are capable of producing cotton.

The mean annual temperatures (F.) of the principal cotton-growing areas are : *Queensland*—south-west, 69·3° ; south, 69·1° ; central, 70·9° ; Brisbane, 68·8°. *New South Wales*—irrigation areas, 62·6° ; north-coast district, 67·6° ; central-western slopes, 63·4° ; and north-west slopes, 65·9°.

The seasons are not well defined, but they are approximately as follows : Spring extends from September to November, summer from December to February, autumn from March to May, and winter from June to August. In Queensland, the Northern Territory and Central Australia, most of the rain falls in the summer months. The conditions are reversed in the south-west portion of the continent, where the summer months are dry and the winter months are wet. At Melbourne the rainfall is fairly well distributed throughout the year, with a maximum in October. The first six months of the year are the wettest on the coast of New South Wales, with a maximum in the autumn.

Early Efforts to Promote Cotton Growing.—Attempts have

been made from time to time to develop a cotton-growing industry in Australia since 1788, when Governor Philip brought cotton seed from South America to plant in Sydney. It is reported that "the plants raised from these seeds flourished and produced much cotton".

As early as 1825 it was established that cotton could be successfully cultivated in Queensland, and samples produced at this period were favourably reported upon in England. The Queensland Crown Lands Act, 1860, offered a premium of £10 for three years, and £5 for the two succeeding years, for every 300-lb. bale of Sea Island cotton produced in the colony and exported to Great Britain. The abnormal condition of the cotton market, brought about by the American Civil War, afforded an additional incentive to cotton production at this stage. Seventeen bales of cotton were exported in 1862. The highest price obtained for the crop was 2s. 2½d. per lb. in Liverpool in 1864; the total bonus paid by the Government in that year amounted to nearly £85,000. In 1870, 14,674 acres were planted with cotton and 4077 bales of lint of 400 lb. each were exported. In the following year, 12,964 acres were planted and 6505 bales of lint were exported. When cotton prices fell on the resumption of normal conditions in America, and Government withdrew the subsidy, the area under cotton shrank considerably. The establishment of a cotton factory, with Government assistance, caused a slight revival in 1890, but the efforts were again relaxed when the factory closed in 1897.

In 1907 the Queensland Government commenced to advance to growers a fair price for all cotton produced in the State. This procedure has been continued until the present time, and has recently been adopted by some of the other States as well, and it is largely responsible for the development that has taken place in the cotton industry. The B.C.G.A. likewise rendered considerable assistance in this connection, for from January 1920, and for a period of five years, the Association guaranteed the Queensland Government a price of 1s. 6d. per lb. of lint delivered to them in Liverpool for sale. The Association's loss in the transaction was limited to a sum of £10,000, and this amount was soon exhausted.

The erroneous assumption that "cotton is a black man's crop", and that the high cost of Australian labour must militate against the profitable cultivation of cotton, has apparently caused Australia to be neglected, to a certain extent, in connection with the activities that have been directed of recent years to increase the production of cotton within the Empire. That this assumption is fallacious is well illustrated by the United States Census Returns, which show that three-fifths of the American cotton crop is produced by white men, and that two-thirds of the farms in the cotton belt are operated by them. Moreover, cotton farms operated by white owners produce the highest yields, and these are followed in order by those of white tenants, negro tenants, and negro owners. In any case, the high cost of Australian labour is, in a large measure, compensated for by the abundance and cheapness of the land. Australian cotton ripens six months later than the American crop; it is therefore due to arrive in Liverpool when the market is more or less depleted of American cotton, and it thus benefits by the "carrying charges" paid on American cotton. Unfortunately Australian cotton pays much higher freight charges than American cotton.

Recent Investigations.—In 1920–21 I was commissioned by the Australian Cotton Growing Association, which has now become merged in the British Australian Cotton Association (B.A.C.A.), to visit Australia for the purpose of investigating and advising as to the possibility of developing the cotton-growing industry. I found that, although cotton was being grown in a desultory manner in many parts of Australia, it was only in Queensland that efforts had been made to produce it on anything approaching a commercial scale. Even in this State the farmers had little knowledge of the crop's requirements, and the seed available was a hopeless mixture of American, Brazilian, Egyptian, and Sea Island varieties.

I came to the conclusion that many parts of Queensland, New South Wales, and in a lesser degree the irrigated areas in the south of the continent, are well adapted for cotton production; though in existing circumstances it is advisable for a farmer to restrict his cotton plot to an area which he and his family can cultivate and pick unaided. Further,

that cotton should be considered as an adjunct to diversified agriculture rather than as a primary production.

I recommended that a sufficient supply of pure seed should be raised to replace the existing mixture, and I suggested that Durango, or some similar variety of long staple Upland cotton, would probably give the best results. Moreover, it is apparent that, owing to the high cost of living and heavy freight charges due to Australia's remoteness from the markets, it is desirable to encourage the production of cotton of the highest quality possible.

Through the courtesy of the United States Department of Agriculture, I was able to procure a supply of pure Durango seed for experimental purposes, and it is gratifying to record that this has proved the most generally successful variety up to the present. It is reported that the supply of seed of this variety had been sufficiently increased to plant 1000 acres in the 1924-25 season, and this would produce seed sufficient to plant the whole Queensland crop in the following season. The Agricultural Department is arranging for pure seed areas grown by communities of farmers who have expressed their desire to co-operate in maintaining the purity of the seed and in increasing the quantity for distribution.

I urged the importance of conducting properly controlled experiments throughout the country to determine the best planting season, the most suitable cultural methods, and the variety or varieties best adapted for particular districts. I pointed out the danger from disease attaching to the system of ratoon cultivation in vogue, and for a similar reason the importance of exterminating the numerous wild perennial cotton plants scattered all over the country.

As I found the conditions prevailing in the irrigated areas similar in many respects to those of the irrigated south-west of America, where Pima-Egyptian cotton is successfully grown, I suggested that this variety of cotton should be tested in the Australian irrigated districts. The United States Department of Agriculture also very courteously supplied the necessary seed for this purpose. Although the experiments conducted with this seed indicate that the growing season in the Australian irrigated districts are too restricted for the successful cultivation of this cotton, still it is possible that,

by selection, an early maturing strain could be raised to meet the purpose, for success was not attained with it in the irrigated south-west of America until a similar procedure was adopted. In any case there is little doubt that long staple Upland cotton of first-class quality could be grown in these areas with advantage. In the irrigated south-west of America cotton is profitably grown as a subsist crop in the young fruit orchards until the trees come into bearing, and it is probable that this scheme of planting could be usefully followed in Australia.

Pests and Diseases.—The insect pests of Australian cotton are mostly those common to other cotton-growing countries. Unfortunately the pink boll-worm has been discovered to be prevalent in Western Australia, in the Northern Territory, and more recently in Queensland. In Queensland one of the most serious insect pests of cotton is the larvae of the peach moth (*Dichrocosis punctiferalis*), which not only injures the bolls by its own activities, but provides a means of entry for fungus spores which induce internal boll rot. The maize worm, *Chloridea obsolata*, was likewise very troublesome in the 1924 season.

The prevalence of fungus diseases and internal boll rots are largely due to punctures made by the large Pentatomid bug, *Tectacoris Banksii*, which is locally known as the Harlequin or Chinese bug. In this connection the Pentatomid bug is even far more troublesome than the *Dysdercus* bugs.

Simon's Heaters are being erected at the ginneries in Queensland to treat all seed that is distributed for planting purposes in order to check the spread of the pink boll-worm; but the regrettable practice of ratooning, which is very prevalent, seriously hampers the Government's efforts to keep the pest in check.

QUEENSLAND.—During the last few years, great enthusiasm has been aroused in cotton growing in Queensland, largely owing to the relatively high prices advanced by the Government for the crop, and to the arrangements effected by the B.A.C.A. for ginning and handling the crop. The 1925 crop is estimated at 17,000 bales.

The Government controls the industry, and the Cotton Industry Act of 1923 stipulates that: (1) the Government takes power to acquire all cotton grown in the State, at prices

fixed by the Governor in Council ; (2) no cotton seed may be sown other than that supplied by the Department of Agriculture ; and (3) no ratoon cotton is to be grown, and all cotton plants shall be destroyed by a fixed date each year.

The provision with regard to ratoon cotton met with serious opposition and it has been rescinded, for owing to the high cost of labour it has been found necessary to ratoon cotton, and practically one-half of the crop this season (1925) has been ratooned.

Experiments conducted by the Department of Agriculture in 1924-25 show that the annual plots gave very much bigger yields and greater profits than the ratooned plots. The quality of the lint from the annual plots was likewise superior to that from the ratooned plots. The ratooned lint was inferior in drag and lustre, and was also shorter in staple and the fibres were more irregular in length.

Government Crop Price Guarantee.—For the five years 1919 to 1923, Government guaranteed the growers a price of $5\frac{1}{2}$ d. per lb. for all seed cotton produced in the State. For the season ended July 31, 1924, Government guaranteed the growers a price of 5d. per lb. for seed cotton of good quality, while cotton of inferior quality got a proportionately lower price, the price for ratoon cotton being 3d. per lb., for experience has shown that it is inferior to the annual growth when produced under similar conditions. The cotton has to be delivered on the railway in each case.

The guarantee is restricted to an area of 50 acres for any one person or company. Seed cotton of good quality is defined as—seed cotton which is free from disease, and not immature, dirty, stained or otherwise damaged. Any profits accruing after deducting the cost of ginning, baling, and marketing the cotton is to be divided *pro rata* amongst the growers. All grading and inspection of cotton at the ginneries is under the supervision and direction of officers of the Department of Agriculture.

Some 1760 bales of Queensland cotton that were received in Liverpool during the period July to September 1923 were classified for the most part as “Barely Middling Fair, $1\frac{1}{16}$ – $1\frac{1}{8}$ inch staple”, and were valued at from 100 to 150 “points on” the succeeding month’s Futures.

A representative series of samples of Queensland cotton

collected by the Government Cotton Classifier in 1925 were examined by brokers; the values assigned to them ranged from $1\frac{1}{4}$ d. to $4\frac{1}{2}$ d. per lb. above April (1925) American Futures. The series comprised seven samples of Durango, and one each of Lone Star and Acala.

Handling the Crop.—Arrangements for handling and marketing the crop have been effected by an agreement, dated September 1922, which the Government have contracted with the B.A.C.A. for a period of four years. This agreement stipulates that the Association should, before June 30, 1924, erect, in Queensland, so many ginneries as may be required for treating all seed cotton grown in the State, and at least one cotton-seed oil mill for the treatment of surplus cotton seed. The Association undertook to expend at least £150,000 in the erection of ginneries and oil mills before July 31, 1924. Government pays the Association $1\frac{1}{4}$ d. per lb. for all lint ginned, pressed, baled, and delivered on railway trucks ready for shipment. All cotton seed, other than that required by Government for cotton growers for planting purposes, and for experimental plots, all linters and by-products, are the property of the Association; but the Association is to pay the Government such a price for them as may be mutually agreed upon. The Association undertakes to despatch all seed for planting purposes, and charge on behalf of Government a price of $\frac{1}{2}$ d. per lb. for it.

Government appoints the Association their sole agent for the shipping and sale of cotton; the Association being entitled to a commission of $1\frac{1}{2}$ per cent for all lint delivered, and a commission of $2\frac{1}{2}$ per cent on all lint that they sell.

The ginneries erected by the Association are equipped with American saw gins of the air blast type, and presses which turn out the American type of bale weighing about 500 lb.

Cotton Grading.—The widely differing soil and climatic conditions under which the crop is grown results in the production of cotton of different character, even from the same variety. With the object of facilitating marketing, encouraging clean picking and the resultant production of better cotton, a system of grading has been introduced.

Although under the conditions of the Government guarantee of $5\frac{1}{2}$ d. per lb. of seed cotton, which terminated in 1923, a rough-and-ready system of grading was practised,

whereby cotton was divided into three classes: (1) good annual, (2) inferior annual, and (3) ratoon, the limitations of this system soon became apparent as the crop increased in size.

Serious attention was first devoted to grading early in 1923. At the outset the inexperience of the ginnery staff and the lack of trained graders made it necessary to limit the number of grades of seed cotton and to make them as distinct as possible. Further, it was decided that the grades of seed cotton should be made to correspond as closely as possible to the universal lint standards. Those recognised for 1923 were as follows:

Seed Cotton Grade.	Corresponding Lint Grade.	Guaranteed Price per lb. of Seed Cotton.
A	{ Middling fair } { Good middling } . . .	5½d.
B	{ Good middling } { Strict middling } . . .	5½d.
C	Middling . . .	5½d.
D	Strict low middling . . .	5d.
E	Lower grades . . .	4d.
F	" " . . .	3d.

The bales were marked with the grade letter, numbered and marked with the name of the ginnery.

A sample set of seed cotton grades was supplied for reference at each ginnery and men were temporarily appointed to grade the cotton. Under these conditions it is not altogether surprising that the grading was not particularly well done, but it was a good beginning and served to demonstrate the necessity for more careful grading.

In September 1923 an expert cotton classer was appointed and steps were taken to train a staff of assistants. Young men who had been trained in wool classing proved to acquire the necessary knowledge of cotton grading most rapidly, and eight of these men were given a course of training for a period of six months by the cotton classer. As a result the grading of the 1924 crop showed great improvement.

It was decided to make greater differentiation between the top classes of cotton, also between the poorer and lower classes of cotton, and to introduce three grades for spotted or immature cotton. As finally approved, the grades for the 1924 season were as follows:

Seed Cotton Grade.	Corresponding Lint Grade.	Guaranteed Price per lb. of Seed Cotton.
A	Middling fair	5d.
B	Strict good middling . . .	5d.
C	Good middling	5d.
D	{ Strict middling }	5d.
	{ Middling }	
E	{ Strict low middling } . . .	4½d.
	{ Low middling }	
F	{ Strict good ordinary } . . .	4d.
	{ Good ordinary }	
G	{ Strict ordinary }	3½d.
	{ Ordinary }	
1X	Grades of immature and spotted seed cotton	5d.
2X		4½d.
3X		3½d.

As it is obviously desirable to encourage the production of the greatest possible number of bales of the top grades, both to maintain the reputation of Queensland cotton and with the view of securing the best prices, it was decided to place a premium on the two top grades. The grades and guarantees adopted for 1925, and these have been generally adopted throughout Australia, were as follows :

Seed Cotton Grade.	Corresponding Lint Grade.	Guaranteed Price per lb. of Seed Cotton.
A	Middling fair	5½d.
B	Strict good middling . . .	5½d.
C	Good middling	5d.
D	{ Strict middling }	4¾d.
	{ Middling }	
E	{ Strict low middling } . . .	4½d.
	{ Low middling }	
F	{ Strict good ordinary } . . .	4d.
	{ Good ordinary }	
G	{ Strict ordinary }	3½d.
	{ Ordinary }	
IMMATURE AND SPOTTED GRADES		
1X	{ Good middling to strict } . . .	4¾d.
	{ Good middling spotted } . . .	
2X	{ Strict low middling to } . . .	4½d.
	{ Middling spotted }	
3X	{ Strict ordinary to }	3½d.
	{ Strict good ordinary }	

The seed cotton arrives at the ginneries in grain sacks or wool packs, and individual consignments are weighed under the

supervision of a Government check-weigher. A Government grader is stationed at each ginnery, and as the different lots of cotton arrive he slits open the packages and extracts sufficient cotton to enable him to judge for grade according to colour and the quantity of trash it contains. A recognised tare is deducted for the packing material, and the cotton is then placed in a large shed and stacked separately accordingly to grade.

Each grade is ginned separately. In order to check the grade of the lint a hole is cut in the slide, down which the lint passes from the condenser to the press box, which enables a sample to be drawn of any part of any particular bale. This practice obviates the necessity of slashing the bales for sampling after they have been pressed ready for shipment.

The mixed type of cotton formerly grown was somewhat uneven in staple, but was roughly classed as $1\frac{1}{8}$ -inch staple. Now that this is being gradually replaced by Durango, attention is being directed to stapling the Durango cotton. As the packages of this cotton are slit open for grading, locks of cotton are pulled by the classer to judge the staple length, and the packages are then marked with the grade letter and the staple number.

The staple length is denoted by the use of numbers, as follows :

No. 1	denotes	$1\frac{1}{16}$	inch staple.
" 2	"	$1\frac{1}{8}$	" "
" 3	"	$1\frac{3}{16}$	" "
" 4	"	$1\frac{1}{4}$	" "

The cotton is stacked according to the grade and staple, and the different lots are ginned separately.

Production Costs.—The average cost of seed cotton production per acre on four farms in the Dawson Valley has been calculated by the Agricultural Department as follows :

	S.	D.
Ploughing twice	33	9
Harrowing twice	5	3
Planting	3	9
Horse cultivation	8	3
Thinning plants	4	3
Picking 800 lb. seed cotton at 2d. per lb.	146	8
Bagging and cartage	6	6
Total	208	5

Cost of producing seed cotton = 2.84d. per lb.

It should be noted that this estimate takes no account of interest on the capital value of the land, cost of fertilisers, and seed for planting.

As it requires 3 lb. or more of Queensland seed cotton to yield 1 lb. of lint, it follows that the first cost of the best lint is 1s. 3 $\frac{3}{4}$ d. per lb. To this amount has to be added the cost of transporting the seed cotton to the ginnery; 1 $\frac{1}{4}$ d. per lb. of lint for ginning and baling; a commission of from 1 $\frac{1}{2}$ to 2 $\frac{1}{2}$ per cent payable to the B.A.C.A.; and freight and charges from Australia to Liverpool, which are approximately estimated at 1d. per lb. of lint. Against this there is the value of the seed sold for planting at $\frac{1}{2}$ d. per lb., on which Government bear the cost of railway transport, and the value of the surplus seed and linters. It is therefore conceivable that the lint may cost the Government more than its English market value before it even leaves Australia.¹

The question of providing a local demand for the crop has already received attention. A spinning mill has been established at Sydney, and it is anticipated that a moderate tariff duty will enable it to supply a large proportion of the local requirements in cottons and threads, for both manufacturing and domestic purposes. In 1925 1000, bales were used.

Area and Yield of Cotton.—Official estimates give the areas planted with cotton and the yield of seed cotton as follows:

Season.	Area brought to Bearing.	Yield of Seed Cotton.	Average Yield of Seed Cotton per acre.	Total paid to Growers.
	Acres.	lb.	lb.	£
1919-20	166	45,581	275	1,038
1920-21	1,967	922,778	469	21,145
1921-22	8,176	3,878,673	474	88,460
1922-23	28,695	11,769,502	410	264,400
1923-24	35,373	15,201,784	430	315,208
1924-25	60,000 *	..	..	..

* Estimated.

Note.—Drought adversely affected both the yield and the quality of the 1922-23 crop.

Land Tenure.—Enormous areas of land suitable for cotton growing are available, both freehold and leasehold, and within comparatively easy reach of railways. Over

¹ A recent estimate of the cost of placing one pound of lint on the Liverpool market is given as 15·6d.

3 million acres of new land in the Burnett and Callide Valleys, in South Queensland, have been recently thrown open for settlement.

Crown lands may be acquired under a "perpetual lease". The land is generally valued at from £2 10s. to £3 10s. per acre, on which rent is charged at the rate of $1\frac{1}{2}$ per cent for the first fifteen years, which is less than 1s. per acre per annum. For the first two years following selection no rent need be paid. At the end of each succeeding period of fifteen years the land is revalued and rent is charged accordingly; the new rent is determined by the Land Court at $1\frac{1}{2}$ per cent on the unimproved freehold value of the land. The farmer is therefore not encumbered at the beginning of his operations by a heavy mortgage, and his capital is available for developing his farm. Similarly favourable conditions for acquiring land obtain in all the other States of Australia.

Cotton Cultivation.—Fortunately the climatic conditions prevailing in Queensland are such that a white man is able to perform all the necessary agricultural operations associated with cotton growing without serious discomfort. Experience has shown that a man with a medium-sized family can perform all the work on a cotton farm up to 10 acres without outside assistance. Given the necessary and proper implements, he could probably cultivate up to 30 acres, but could not pick more than one-third of this area.

In many cases farmers have planted more cotton than they have been able to cultivate properly with the labour available, and much disappointment has resulted. There is thus a tendency for individual areas to decrease in size year by year, and it is unlikely that large plantations will prove a success. Larger yields per acre are being obtained by more intensive cultivation, and this procedure deserves every encouragement.

The irregular and, in certain seasons, scanty rainfall proves a handicap to cotton growing, but the farmer is learning by experience to mitigate this difficulty by fallowing his land through the winter and cultivating to conserve soil moisture. Cotton has, however, proved more drought-resisting than maize, which is the chief competing crop. In a similar manner the farmer is learning which are the best

types of soil, the best methods of cultivation, plant spacing, time of planting, and other essential details.

At present cotton cultivation is mainly confined to the South Coast, Darling Downs, and Maranoa districts, Rockhampton being the northern limit. But the potential cotton area is very extensive, reaching from the border of New South Wales to Mackay, a distance of 500 miles, and extending for 200 miles inland.

It must not, however, be inferred that the whole of this area is suitable for cotton growing, for in certain districts the rainfall is too heavy, too light, or too uncertain for profitable cotton cultivation.

The soils of the country are likewise extremely variable, and even in quite small areas are often decidedly patchy. The soils of the Darling Downs are chiefly of a heavy, black, clayey nature, which crack badly in a dry spring, and the cotton planted on them suffers from drought; on the other hand, during spells of wet weather it is impossible to get on the land, and weeds get the upper hand. There are, however, in this area alluvial flats that offer much better prospects.

In the country between Toowoomba and Brisbane there is much land that consists of grey and brown loams with a subsoil of clay over gravel, which is capable of producing excellent cotton, and this is the region where cotton was chiefly grown in former days. In the Kingaroy district the brown forest lands, the grey scrub soils, and the sandy alluvials have been proved well suited for cotton. In the large watershed of the Burnett, excellent cotton land is likewise found, and cotton produced in the Upper Burnett Settlement, in 1925, was the best in Queensland.

Unfortunately there is a remarkably small population available for the production of cotton. The total population is only 800,000, of whom one-half resides in the towns, and the remainder is called upon to provide labour for a large sugar industry, enormous pastoral areas, fruit and wheat growing, and the mining industry. It will thus be seen that any great extension of the cotton industry is primarily dependent upon closer settlement. Cotton is a valuable cash crop and provides the new settler with a return in about eight months.

Planting begins with the arrival of the rains in October or

November, and this usually allows ample time for the crop to mature before the frosts that generally occur in July. The seed is sown in lines 4 to 5 feet apart, and plants in the lines are thinned out to about 9 inches apart. An average of four cultivations are given to the crop, and generally there are three pickings.

The importance of winter fallow is emphasised to conserve the moisture in the soil in dry periods that frequently occur during the growing season. At the Monal experiment farm, 12 acres that were ploughed in May 1924, and kept fallow in the winter, gave a yield of over 1200 lb. of seed cotton per acre. An adjacent block which was not ploughed until August yielded only at the rate of 650 lb. per acre.

The E.C.G.C. has secured the services of an officer of the Indian Agricultural Department, who has been lent to the Queensland Government for a period of three years; this officer has now been appointed Director of Cotton Culture in the State. The Corporation has also provided the services of an entomologist for work in connection with cotton pests in Australia, and is contributing to the cost of the experiment station and research work to be undertaken in Queensland and New South Wales.

Although great progress has been made in propagating Durango seed to replace the mixture that was formerly grown, the total elimination of the latter is likely to be unduly protracted by the practice of ratooning cotton. Much research work will have to be conducted before satisfactory types of cotton, adapted to the varying conditions of the country, can be produced.

Plant Breeding and Research Work.—A Central Research Station has been established at Callide, between Rockhampton and Gladstone. In the Upper Burnett country a subsidiary station has been located at Monal, while in the south-eastern area experimental work is being conducted at Gatton Agricultural College. The chief object of these stations is plant breeding, but experiments are likewise being conducted in various cultural problems. A great deal of attention is being devoted to Durango cotton, for it seems that it is adapting itself to local conditions, and variations have been noticed in the character of its lint, habit of growth, earliness, and other important characters. It therefore

seems that it may be possible to evolve a new type superior to the original one.

It is unlikely that one type of cotton will meet the requirements of so large an area as the Queensland cotton belt, so breeding work is being conducted on Acala, Lonestar, and Webber 49, while the following varieties are being tested on a small scale: Delios, Delta type, Express, Lightning, and Webber; these are all American Upland cottons. What is aimed at is a staple averaging $1\frac{3}{8}$ inch, in order that a premium of about 300 points may be eventually secured for the bulk of the crop, so as to counteract the handicap of a high cost of living and high freight charges.

NEW SOUTH WALES.—Next to Queensland, most progress has been made in cotton growing in this State, and especially in the northern portion, where the soil and climatic conditions resemble those prevailing in the Queensland cotton-growing districts. The Government guarantees the growers a fair price for the crop, and have effected an arrangement with the B.A.C.A. for the handling of the crop similar to that operating in Queensland.

WESTERN AUSTRALIA.—The north-western portion of this State offers the most promising conditions for cotton growing, but unfortunately labour is scarcer than in other portions of the Commonwealth. As there is stated to be an aboriginal population estimated at 26,000, there appears to be a possibility of employing them for cotton growing in districts where the climatic conditions are too trying for white men.

NORTHERN TERRITORY.—Although many parts of the Northern Territory are well adapted for cotton growing, and experimental plantings have given most satisfactory results, the country is sparsely populated and there is a great lack of transport facilities. A perennial variety of cotton of Sea Island parentage, that was introduced many years ago, is widely distributed throughout the country, and is a nursery for the propagation of the pink boll-worm and other insect pests. Unless stringent measures are taken to exterminate them, these plants will prove a serious menace to cultivated cotton.

IRRIGATION SETTLEMENTS.—In the irrigation settlements of New South Wales, Victoria, and South Australia, Government have under consideration a large scheme for developing

the valley of the River Murray and its tributaries. It is estimated that the completion of this project will place about 2 million acres under irrigation by 1928. At present there is an area of 200,000 acres under irrigation, which supports a population of about 75,000 people.

Although it appears doubtful whether the frostless season, October to April, is sufficiently protracted for the cultivation of Egyptian cotton, there is every prospect that long staple Upland cotton could be successfully grown in these areas, both as a separate crop and in conjunction with young fruit trees. The State Governments concerned are willing to offer cotton growers guarantees similar to those offered in Queensland. The introduction of settlers on a large scale forms part of the Government's scheme for development.

EXPORTS OF AUSTRALIAN COTTON
(400-lb. bales.)

Year.	Exports.	Year.	Exports.	Year.	Exports.
1906	30	1913	90	1920	260
1907	40	1914	40	1921	770
1908	20	1915	10	1922	3,130
1909	20	1916	20	1923	9,760
1910	90	1917	80	1924	12,500
1911	120	1918	100	1925	11,000 *
1912	90	1919	30		

* Estimated.

CHAPTER X

MINOR COTTON-GROWING COUNTRIES

EUROPE.—Bulgaria. Greece. Italy. Spain.

ASIA.—Afghanistan. Dutch East Indies: Java—Madura—Timor—Sumatra—Flores. Indo-China. Japan—Chosen (Korea). Palestine. Persia: Decreased production since 1914. Philippines. Siam. Turkey: Cotton cultivation in 1859—Later development of the industry—German Levantine Cotton Company—Effects of the War.

AFRICA.—Belgian Congo: Vast areas available for cotton—Native cotton industry long established—Government control—American cotton grown—Cultural operations. French Colonies: Algeria—French West Africa—Togoland (Mandated)—French Sudan—French equatorial Africa—Madagascar. Italian Colonies: Eritrea—Somaliland. Portuguese Colonies: Angola—Moçambique—Lourenço Marques—Inhambane.

AMERICA.—Argentine: Cotton-producing possibilities—Land tenure. Chile. Colombia: Cotton grown for many years—Cotton cultivation—Land tenure. Dutch West Indies: Surinam—St. Martin and St. Eustatia. Ecuador. Guatemala: Weevil-eating Kelep. Hayti and San Domingo. Mexico: Cotton cultivated prior to Spanish Conquest—Ample land and labour available—Cotton-growing districts—Origin of Durango cotton—Cotton production. Nicaragua. Paraguay: Good prospects for cotton. Peru: Ancient cotton industry—Climate and topography—Cotton-growing areas—Decline of the rubber industry favourable for cotton—Varieties of cotton grown—Handling the crop—Pests—Cotton production. Porto Rico. San Salvador. Uruguay. Venezuela.

AUSTRALASIA.—New Caledonia. New Hebrides. Society Isles. New Guinea.

EUROPE

BULGARIA.—In Bulgaria the most favourable conditions for cotton growing are found in the southern portion of the country.

Kaskovo is the type of cotton principally grown, while Turkestan and Upland American cotton are grown to a smaller extent; these cottons have a staple of $\frac{9}{16}$ — $\frac{13}{16}$ inch, $\frac{5}{8}$ —1 inch, and $\frac{3}{4}$ — $1\frac{3}{16}$ inch respectively.

The planting season is April, and picking takes place in September. The area under cotton increased from 1900 acres in 1911 to 7000 acres in 1922, and the production

increased from 880 500-lb. bales to 3440 bales in the same period.

The bulk of the crop is employed for local domestic requirements, and little is exported.

GREECE.—The total area under cotton in Greece is about 23,000 acres, chiefly in Livadia and Serres. The cotton grown is of a mixed character, the varieties being allied to *G. hirsutum*.

Attempts to grow Egyptian cotton have not proved very successful, and its cultivation has been abandoned.



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The whole crop amounts to about 9300 500-lb. bales, which is all consumed in the local mills.

SALONICA.—Some 7000 bales of cotton, American and native, were at one time produced in Salonica, but records as to the present production are not available.

ITALY.—About 9000 acres are planted with cotton in Italy, and chiefly in Sicily, in the provinces of Catania and Syracuse, close to Terranova, and Girgente. Half of the crop is grown under irrigation, and yields at the rate of 1000 lb. of seed cotton per acre, while the rain-grown crop yields at the rate of 600 lb. of seed cotton per acre.

The principal enemies of the crop are Rust and the cotton

worm. The varieties grown are American Upland, Biancavilla, and Terranova. The staple of the cotton is approximately 1 inch. Planting begins in March and picking in September.

The total crop amounts to about 5000 500-lb. bales.

SPAIN.—Cotton cultivation in Spain dates back to A.D. 200, but it declined in the eighteenth century. The districts that are considered to be the best suited to the crop are the low parts of the valley of the Guadalquivir, and the coastal zone up to Almeria, and even to Valencia and Castellon.

There are said to be over 2 million acres suitable for cotton



production as a rain-grown crop, and more than a million acres of irrigated land.

A Commission which was appointed by the Catalan Cotton Committee recently investigated the cotton-growing experiments in progress in Jerez, Malaga, Murcia, Valencia, and the province of Seville. Their report is most encouraging. It is claimed that the land will produce cotton, equal in quality to that grown in the United States, at the rate of 440 lb. per acre, and that 500,000 acres would produce sufficient cotton to meet the demands of the Spanish mills.

Farmers in the Seville district are co-operating enthusiastically with the Catalan Committee in their efforts to develop the industry.

A project is on foot, under Government control and

support, to drain some 90,000 acres of land on the left bank of the Guadalquivir River, and it is considered that the need of land for cotton growing will give additional impetus to the reclamation scheme in this district.

ASIA

AFGHANISTAN.—Cotton is grown in Afghanistan for local consumption, and a variable quantity finds its way into India ; that known as Kabul compares favourably with Cambodia cotton. Cotton piece goods are likewise exported from Afghanistan into India.

DUTCH EAST INDIES.—Java, Madura, Timor, Sumatra, and Flores. The cotton crop of the Dutch East Indies is rather a variable one, on account of the uncertainty of the climate. Rains for the planting season are irregular, and excessive moisture is often prevalent during the picking season.

Caravonica cotton is grown in the island of Flores. In Timor a small amount of American cotton is grown. In the other islands, native varieties are grown with a staple of about $\frac{7}{8}$ inch, and attempts to introduce exotic varieties have failed, chiefly on account of the unfavourable climate.

The *Earias fabia* boll-worm and the cotton worm, *Alabama argillacea*, are the most troublesome insect pests.

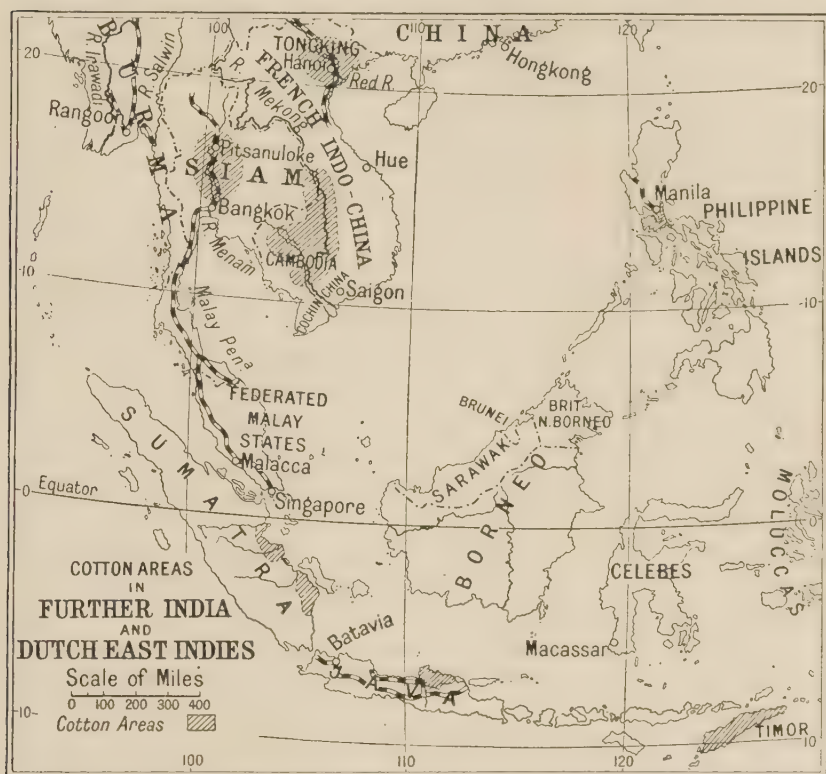
Primitive machines, worked by the foot, are in use for ginning purposes, so that most of the exports are in the form of unginned cotton. The average annual exports of cotton from the Dutch East Indies for the period 1911–20 amounted to nearly 11 million lb. of seed cotton, and 3450 500-lb. bales of lint. The principal markets for this cotton are Marseilles and Japan.

INDO-CHINA.—The total area under cotton in Indo-China is estimated at 50,000 acres. In 1914–15 the crop amounted to 13,460 500-lb. bales, and in 1920–21 to 5970 500-lb. bales. Cambodia cotton, which has proved such a success in India, is grown along the valley of the Mekong River, which passes through the province of Cambodia. Cotton is also grown to a less extent in the valley of the Red River, in the province of Tongking.

In Cambodia, cotton is chiefly grown on the river banks, on the light soils that are inundated and fertilised by the

Mekong. Planting takes place on the subsidence of the floods in October. The crop matures in March, which is also the rainy season and is prejudicial to picking operations. The cotton is short in staple, and is principally exported to Japan.

Recently attempts have been made to grow cotton on the red soils that are found in the higher lands. In order to



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avoid injury to the crop by the rains, the seed is sown in July, and picking takes place in January and February. Fair results have been obtained, the yield being higher and the staple longer than on the river banks.

Cotton exports in 1923 and 1924 amounted to 14,940 and 13,900 500-lb. bales respectively.

Not only in Indo-China, but in Algeria, Senegal, Ivory Coast, French Guinea, Togo (mandated), Dahomey, French Sudan, and the Lake Chad region in Africa; and New

Caledonia, New Hebrides, and the Society Isles, in Australasia; the French Colonial Cotton Association, which was established in 1903, has worked on lines similar to those of the B.C.G.A., and it is largely due to its activities that the exports of cotton from French colonies increased from 11,500 500-lb. bales in 1902-3 to 37,000 500-lb. bales in 1913-14. Production fell considerably during the late war, but strenuous efforts are being made to re-develop the industry, and the total exports from French colonies in 1923 and 1924 amounted to 23,955 and 25,886 500-lb. bales respectively.

JAPAN.—The average annual production of cotton in Japan from 1878 to 1891 was about 138 million lb. of seed cotton. The area under cotton decreased from 241,000 acres in 1887 to 7000 acres in 1911, and the latter acreage has continued to be planted since that date. During the latter period the amount of cotton produced has likewise remained stationary at about 4500 500-lb. bales.

At the present time cotton is principally grown in Kiushiu and neighbouring islands. Planting takes place in April and May, and picking begins in September. The land is fertilised by applying oil-cake and fish guano in the furrows between the young seedlings. The native varieties of cotton in use produce a short, harsh staple.

It is to Chosen rather than Japan that the latter country looks for increased supplies to meet the demands of her rapidly developing cotton manufacturing industry.

Japan's annual consumption of lint now amounts to 2 million 500-lb. bales, the bulk of which emanates from India and China, which is equivalent to about one-tenth of the world's cotton crop.

The President of the Master Cotton Spinners' Associations, speaking at the annual meeting of that body on February 19, 1926, stated that it was difficult to see how the menace of Japanese competition was to be successfully met and he could not see how Lancashire goods could live against Japanese competition under present circumstances. In Japan girls of ten worked for food and clothing only, without payment of wages. Exports to Indian mills were subsidised by the State. The mills were run twenty hours a day in two shifts, and women were employed during the night.

CHOSEN (KOREA).—Formerly native cotton, *G. Nanking*,

the staple of which is similar to Chinese cotton and the lower Indian grades, was grown all over Korea. When the country came under the control of Japan, it was renamed Chosen, and the Japanese at once instituted energetic measures to develop the cotton-growing industry.



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A Cotton Association was inaugurated to encourage the cultivation of American cotton, and the Government granted a subsidy for this purpose.

As the result of cultural tests conducted at the Government experiment farm, the American variety King's Improved was selected as the kind best suited for cultivation in the southern portion of the country; but native cotton continues to be grown in the north.

In 1910 the cotton crop amounted to 14,200 500-lb. bales.

In 1921 there were 264,000 acres under American cotton and 99,000 acres under native cotton ; and the total crop amounted to over 88,000 500-lb. bales. The bulk of the exports in 1920, estimated at 22,000 bales, went to Japan, but in the same year Chosen imported over 5000 bales for local consumption. Japan and Chosen are estimated to have produced 200,000 bales in 1925.

Besides giving a much better ginning out-turn and producing a superior staple, the American cotton yields at the rate of 530 lb. of seed cotton per acre, as compared with 370 lb. of seed cotton yielded by the native variety. Thirty model farms for American cotton, efficient ginneries, and a well-organised system of seed distribution, have been established in the south. In addition, growers have organised on co-operative lines for the supply of good seed, and also for the financing and sale of the crop.

PALESTINE.—During the American Civil War, cotton was grown in Palestine on the Plain of Phœnicia in the Haifa-Acre district, and considerable quantities of the commodity were produced, but production ceased in 1870. Spasmodic attempts have been made to grow cotton since that date, but no very definite results have been obtained. The soil and climate of the Jordan Valley are regarded as ideal for cotton cultivation, but the crop cannot be grown on a commercial scale until irrigation facilities have been established.

PERSIA.—Marco Polo refers to the production and manufacture of cotton in Persia in 1290. *G. herbaceum* is common, and was probably carried thither by the early Saracens as a cultivated plant. *G. Nanking* and *G. hirsutum* are also met with. The bolls of some varieties open badly and the lint is of low quality, its value being depreciated by contamination with leaf and trash.

Decreased Production since 1914.—Prior to the Great War of 1914, Persia produced 140,000 bales of cotton, chiefly in the northern half of the country. The principal cotton-growing areas are now situated on the southern shores of the Caspian Sea, and in the vicinity of Hamadan, Ispahan, Teheran, and Yezd, where the climatic conditions resemble those prevailing in the adjacent Turkestan territory.

Formerly, nearly the whole of the exports of cotton went to Russia, but the failure of this market caused stocks to

accumulate to a considerable extent, although purchases from India have relieved the situation.

In the interior the rainfall is only 5 inches, and irrigation facilities are altogether inadequate, being entirely dependent on private wells. Near the rivers, where better facilities for irrigation are available, rice is grown. Transport is also bad, and the cotton has to be conveyed to market and port in small bales weighing about 250 lb. It is unlikely that there will



be any considerable development of the industry until the conditions as regards irrigation and transport are improved. Moreover, little has been done to improve the quality of the produce, although Egyptian and American varieties have been introduced.

During the period 1914–21 the average annual production was 10,800 500-lb. bales; from 1922 to 1925 it amounted to 110,000 bales.

PHILIPPINES.—At one time large quantities of cotton were grown for local consumption in several of the Philippine Islands, but the manufacture of cheaper cotton goods in other countries has seriously affected the industry. In 1902

the cotton crop was estimated at 6000 bales. In 1913 the exports amounted to 6100 bales.

In 1905, cultural experiments were commenced in Hawaii to investigate the possibility of developing the industry. Varieties of cotton from all parts of the world were tested ; the best results were promised by Caravonica, Sea Island, and Egyptian. The first-mentioned kind yielded as much as 400 lb. of lint per acre.

It was found practicable to grow these varieties as perennials, and by severe pruning to increase the plant's prolificacy, and to control the harvest so that picking did not interfere with the sugar-cane harvest.

In Hawaii there are reported to be considerable areas available and suitable for cotton growing, situated at a higher level than is found profitable for sugar production.

The principal cotton pest is the cotton boll-weevil, *Amorphaidea lata*, Motsch. ; this pest is widely distributed, and as all bolls that are attacked by it fall to the ground, it is the cause of a serious loss of both lint and seed. The pink boll-worm is also prevalent.

SIAM.—Siam produces a considerable quantity of short staple cotton, which goes principally to Japan. The native cotton of Siam is *G. Nanking*. In 1913 the production of cotton amounted to 5000 bales, but since that date it has fallen considerably.

Cotton is grown chiefly in the Bisnulok and Roi Ech provinces, and almost entirely by small cultivators.

Government owns a ginnery at Pitsanuloke, and it supplies seed free of charge for planting purposes ; some of this seed is imported from Cambodia. The methods of cultivation resemble those of the Chinese, and are fairly intensive. The yield is reported to be as high as 1000 lb. of seed cotton per acre. The average area under cotton during the period 1916-1921 was 11,500 acres.

TURKEY.—Cotton was for many years one of the most important articles of cultivation in Asia Minor. In the sixteenth and seventeenth centuries, Brusa, Adana, and Smyrna were large centres of cotton production. The native Yerli cotton is similar to that grown in Turkestan, *i.e.* *G. herbaceum* ; the bolls do not open wide, so they are plucked whole and the cotton is extracted afterwards by breaking open the dry bolls.

Cotton Cultivation in 1859.—New Orleans cotton was grown in the Cavalla district in 1859, and, according to a report by Vice-Consul Maling, it gave yields of more than 200 lb. of lint per acre. Manure was only applied on light sandy soils. The stronger or clayey soils were considered most suitable for the crop. On light soils, cotton and grain, barley or rye, were grown alternately. On soils of a slight clayey nature, cotton was grown for two consecutive seasons, followed by grain for one season. On stronger clays,



cotton was grown for three consecutive seasons, followed by wheat or maize for one season.

The land was ploughed three or four times with wooden ploughs hauled by oxen; sometimes rather with the object of clearing the land of weeds. Owing to the primitive nature of the implements used, the working was superficial. The seed was sown during March and April, broadcast and also in drills, the latter being 18 inches apart, and a space of 9 inches was left between the plants in the rows when thinning-out took place. Irrigation was not practised, the rainfall at Adana being 26 inches. The plants were hoed three or four times, and when this was done the earth was drawn towards the plants.

The New Orleans plants grew more luxuriantly than the native plants, for the latter rarely attained a height exceeding $1\frac{1}{2}$ feet, whereas the former grew 3 and even 5 feet high. The native cotton produced from 10 to 30 bolls per plant, while the exotic cotton produced from 50 to 80 bolls per plant.

Later Development of the Industry.—In 1860 the Ottoman Government began to make efforts to promote cotton cultivation, and in 1862 cotton production had increased to 50,000 bales, while the production for 1865 is given as 200,000 bales. Apparently in later years production declined considerably, for in 1902–3 it only amounted to 77,000 bales, although it steadily rose to 157,000 500-lb. bales in 1913–14.

German Levantine Cotton Company.—Commencing in 1904, this company endeavoured to develop cotton growing in Asia Minor. They imported good American cotton seed and also Ferghana cotton seed from Russia, and distributed it in selected areas. They provided gins and presses, and financially assisted small farmers who practised up-to-date methods of cultivation. Their original scheme of establishing large cotton plantations under European control was unsuccessful owing to labour shortage, so the policy of small holdings was resorted to.

The Adana vilayet or province was the first area to be dealt with, the soil and climate being favourable for cotton production, and the port of Mersina, which is served by the railway passing through the town of Adana, provided an excellent centre for the collection and export of the crop. Large areas of land are available, with a fertile alluvial soil of a clayey consistency. Generally the conditions resemble those obtaining in the Nile Valley, although the rainfall is heavier. In 1913–14 the total production of cotton in the Adana vilayet amounted to 100,000 440-lb. bales. The cotton produced was white and glossy with a staple of 1 inch, and was ginned in roller gins. It was, however, appreciated that for the proper development of the industry a good system of canal irrigation was required. Progress has been checked both by the war of 1914 and the Turkish massacres of the Armenians, who were the best cotton-growers.

A certain amount of progress was also made in the vilayet of Aidin, where there is much irrigable land available, and Egyptian cotton promised to give good results. The circum-

stance that the vine crop, in the upper part of the valley, had become unprofitable, was likewise conducive to increased cotton cultivation. Transport was facilitated by the proximity of the port of Smyrna. In 1913-14, 30,000 440-lb. bales were produced.

Effects of the War.—Shortly after the late war, cotton cultivation practically ceased, but there is great promise of the industry reviving. Recently 1000 bales of Turkish cotton arrived in Manchester, and the chairman of the Ship Canal Company is reported to have stated that Turkey is expected soon to produce annually a crop of 100,000 bales. The Adana district alone produced 30,000, 80,000, and 90,000 bales in 1922, 1923, and 1924 respectively.

Cotton is now grown in the south-west and south-east parts of Asia Minor, in the vilayets of Adana, Aidin, Aleppo, Mosul, and Mamouretul-Ariz. About one-third of the crop is consumed in the mills of Adana and Tarsus. The country possesses splendid cotton-producing capabilities, and properly exploited might be made a prolific source of supply for the European mills, for, besides the native Yerli cotton, some American Upland varieties show promise.

AFRICA

BELGIAN CONGO.—*Vast Areas available for Cotton.*—The enormous tract of country known as the Belgian Congo covers an area of nearly a million square miles, of which it is estimated that $4\frac{1}{2}$ million acres are well adapted for cotton production. The population of the country is 15 millions, of whom less than 6000 are whites. Except at the mouth of the river, the whole country consists of a tableland more than 1000 feet above sea level, and the climate is one of the mildest in the equatorial world. Less than forty years ago most of the native tribes were inveterate cannibals, but to-day the country is pacified and cannibalism is being exterminated.

Native Cotton Industry long established.—Cotton growing has been a native industry for centuries, and some of the native varieties produce cotton of excellent quality. For many years attempts have been made by the Government to develop the industry; cultural experiments have been conducted with various varieties of cotton in several districts,

and in this connection the B.C.G.A. have also rendered assistance.

American cotton has been chosen as the type best suited to the local conditions.

The chief cotton-growing districts are : Maniema, Lomani, Lasai, and Sankuru south of the equator, and Upper Uelé and Ituri, north of the equator. Cotton growing is almost entirely a native industry. Agricultural inspectors select land suitable for the crop, arrange sowing dates, distribute seed, and generally advise the natives as to the handling of the crop. All seed for planting is either approved or distributed by the Government. After picking, the destruction of all plants is compulsory as a protective measure against pests and diseases.

Government Control.—Government fixes the minimum price to be paid for the crop, and the purchase of cotton is only permitted at duly appointed markets. Well-equipped, up-to-date ginneries have been erected in convenient localities, and an oil-press has been installed at Lusambo to deal with the surplus seed. The estimated production increased from 4000 500-lb. bales in 1920 to 16,000 bales in 1924.

American Cotton grown.—The American varieties which have given the best results are: Triumph, Russell's Big Boll, and Simpkins. The average yield per acre is 176 lb. of lint. The cotton has a staple length of $1\frac{1}{8}$ inch, and it sells on a par with, or at even a premium on, "Middling American".

Cultural Operations.—In the south, planting takes place in December and January, and picking begins in June. In the north, planting takes place in June and July, and picking begins in December. Cotton is mostly grown in quite small plots of about $\frac{1}{6}$ acre in area. The hard work of clearing and preparing new land is done by the men, but the women and children do most of the planting, hoeing, weeding, and picking.

FRENCH COLONIES: ALGERIA.—A certain amount of success has been attained in Algeria in the cultivation of both American and Egyptian cotton, in the districts of Orleansville and Oran, and also in the oases near Bishra and Tolga. Exports of cotton in 1910 amounted to 120 500-lb. bales, and in 1921 to 1100 500-lb. bales.

Water shortage has hitherto been a limiting factor in cotton growing. The rainy season is short and irregular, although the rainfall is at times very heavy, and in the winter the river courses develop into rushing torrents, but, for the most part, dry up during the summer. Irrigation is therefore of primary importance for the agricultural development of the country, and the Algerian Assembly has decided to allocate annually a sum of 21 million francs, in the period 1924-29, for the development of agricultural hydraulics.

FRENCH WEST AFRICA.—In Senegal, Ivory Coast, French Guinea, Togo, and Dahomey endeavours have been made for a number of years to foster cotton growing, which has been practised by the natives from time immemorial, as in British West Africa. Indifferent success has attended these efforts, for in 1920 the total exports of cotton from these colonies only amounted to 6110 500-lb. bales, of which Togo contributed 4350 bales.

In Senegal the unsatisfactory conditions as regards water supply are likewise to be improved by conserving the waters of the Senegal River. Comparatively simple barrages are to be constructed at selected points, and the flood water thus stored is to be distributed as and when it will be most serviceable. Additional funds have been allocated to the Agricultural Department for the training of young farmers in improved agricultural methods, and to popularise the use of light, animal-drawn agricultural implements.

Togo (mandated).—Reference has already been made to German activities in respect to cotton growing in Togo. Two kinds of cotton are grown: one is a form of *G. hirsutum*, which produces a staple of $\frac{7}{8}$ inch; and the other, which is known as Togo Sea Island, produces a staple which varies from $1\frac{1}{6}$ to $1\frac{1}{2}$ inch.

FRENCH SUDAN.—The natives grow cotton throughout French Sudan for local consumption, but the native varieties which they favour yield an inferior lint of short staple. The scanty rainfall is inimical to the cultivation of superior types. Two commercial enterprises are growing Egyptian cotton under irrigation with fair success, and the exports in 1919 amounted to 600 500-lb. bales. Native cotton production is increasing rapidly.

A scheme has been projected to systematise and establish

regular irrigation by the utilisation of the Niger flood, which occurs at a time that is propitious for cotton cultivation.

FRENCH EQUATORIAL AFRICA.—It is estimated that there are about 77,000 square miles of land available for cotton growing in the vicinity of Lake Chad, and where the natives have grown cotton for their own domestic requirements for centuries. Recently a company has commenced planting operations on a commercial scale.

MADAGASCAR.—Some twenty years ago there appeared to be a prospect of developing the cotton industry in Madagascar, but since that date the crop has been neglected, although it is still grown to a small extent by the natives in most parts of the island. The kind grown in the south-west of the island is allied to *G. obtusifolium*: it seems to be resistant to drought and insect attacks, and produces a staple of $\frac{3}{4}$ to 1 inch. In the remainder of the island *G. purpurascens* is found; this produces an inferior lint, and it is proposed to replace it with imported Gujarat seed from India.

The exports of cotton from various French colonies in 1923 and 1924 were as follows:

	Bales of 500 lb.	
	1923.	1924.
Senegal	1340	4170
Sudan	620	370
Guinea	1040	290
Ivory Coast	870	1160
Dahomey	1380	1420
Togo	3270	4400

ITALIAN COLONIES: ERITREA.—In Eritrea, cotton is chiefly grown in the Gash and Barca districts, adjacent to the British Sudan, and the rivers of that name provide the necessary irrigation facilities. It is also grown to a smaller extent on the shores of the Red Sea, where the rainfall is supplemented by irrigation.

Native varieties of cotton have been discarded in favour of long staple American cotton in the Gash and Barca districts, while Sea Island cotton is grown on the shores of the Red Sea.

Improved transport and irrigation facilities would do much to develop the industry.

The annual average exports of cotton for the period 1910-19 amounted to 550 500-lb. bales.

SOMALILAND.—Tree cotton, *G. arboreum*, is grown in Dancalia and Harrar. Egyptian and American varieties have also been acclimatised. Cultural experiments, that were conducted by the Government with Egyptian cotton, yielded as much as 600 lb. of lint per acre.

Considerable interest is being evinced in the possible development of the cotton-growing industry by irrigation. Two rivers are available for this purpose—the Juba, which forms the boundary between Italian Somaliland and Kenya, and the Uebi-Seebeli, which flows parallel with the coast.

In the Juba Valley the soil and climatic conditions resemble those prevailing in the Nile Valley, and the levels are more favourable for irrigation purposes.

The average annual exports of cotton for the period 1911–20 amounted to 340 500-lb. bales.

PORTUGUESE COLONIES : ANGOLA.—Portugal was the first European power to encourage the development of cotton growing in Africa. In 1845 natives of Angola who collected 300 lb. of cotton were exempted from military service. In 1858, 22,000 lb., equivalent to forty-four 500-lb. bales, of cotton were exported; twenty years later the exports had increased to 3500 bales, but a decline then set in, and in 1903 only 152 bales were exported.

In 1906 the Government attempted to revive the industry; an experiment station was established at Catete, sixty miles inland from Loanda, which is the chief centre of production. In certain districts the native residents are compelled to plant a minimum area of an acre of cotton each year.

The areas that are considered best suited for cotton are the well-watered regions in the north, the country traversed by the Bengo River, Amboin and Catumbella, Egito, Laucho, and Cabal in the Benguella region, and in the vicinity of the rivers along the coast from Benguella to Port Alexander.

American Upland is the type chiefly grown. The annual average exports for the period 1910 to 1919 were 480 500-lb. bales. In 1920, 1921, and 1922 they amounted to 870, 1840, and 3297 bales respectively.

MOÇAMBIQUE.—For many years efforts have been made to develop the cotton-growing industry in Portuguese East Africa, both by the Government and various commercial

companies. The most promising results have been obtained in the Manica and Sofala territories, which are administered by the Chartered Company of Moçambique. The territories comprise an area of 65,000 square miles, and have a native population of $\frac{1}{4}$ million.

Early in the present century the company established experimental cotton farms. Attempts to introduce the cultivation of Egyptian cotton were a failure, principally because the rainy season is too restricted for the successful cultivation of this type of cotton, and irrigation facilities were not available. More promising results were obtained with long staple American cotton, and this is the kind that is chiefly grown to-day.

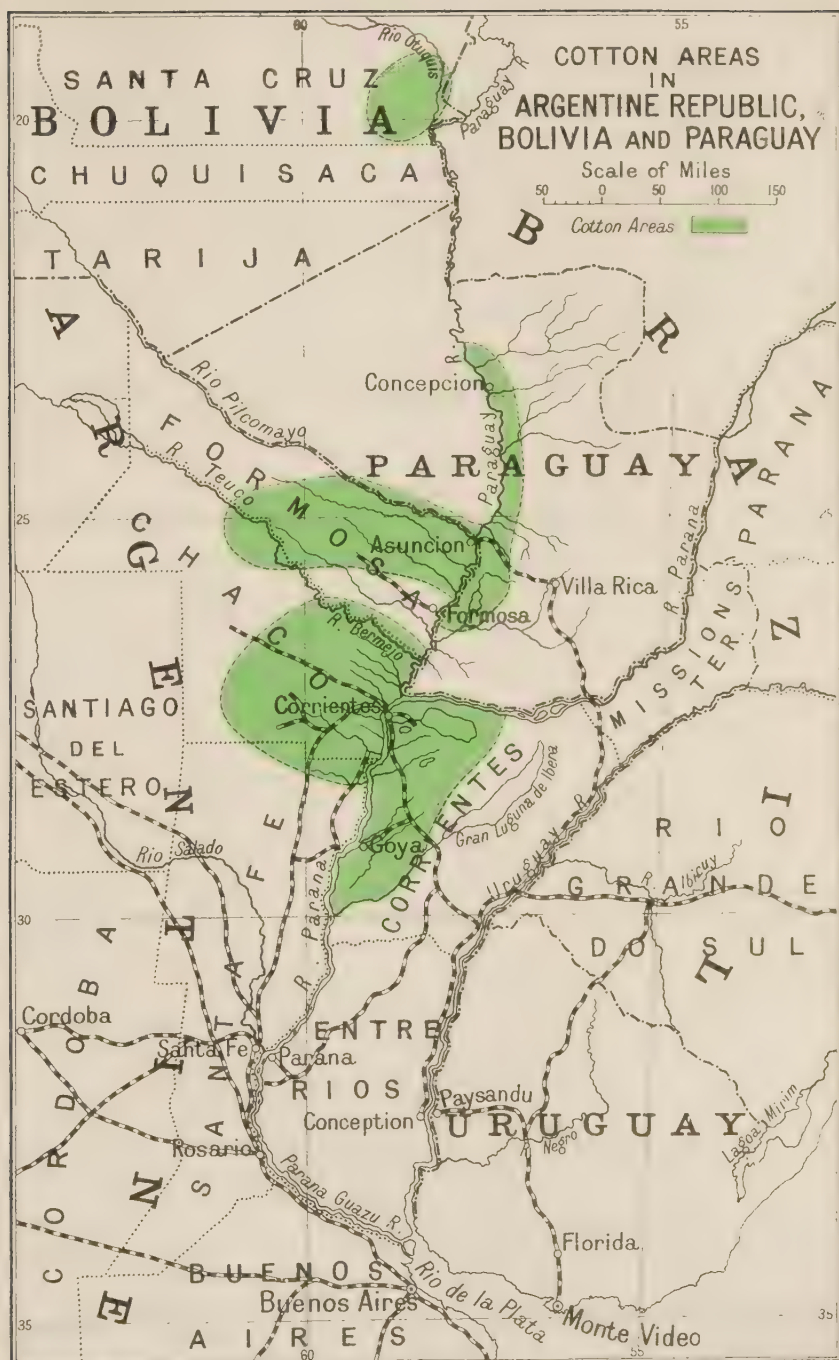
Zambesi Flats adapted for Cotton.—The alluvial flats of the Zambesi Valley are well adapted to the cultivation of this type of cotton. Large areas are flooded during high-water season, and the rich black soil is annually enriched with silt, which serves to maintain its fertility.

In addition to these flats there are large areas of land at a slightly higher elevation that are well suited for cotton cultivation in years of average rainfall. In 1924 it was estimated that 10,000 acres were under cotton cultivation in the Manica uplands. In the valleys of the Buzi and Pungue Rivers there exist large areas where the conditions are similar to those prevailing in the Zambesi Valley. In the Chemba district the natives are good farmers; they produce excellent crops of cotton, and the industry has now become well established.

The production of cotton in these territories from 1918 to 1921 was as follows :

Year.	Production (500-lb. Bales).	Year.	Production (500-lb. Bales).
1918	400	1920	4530
1919	1010	1921	3150

LOURENÇO MARQUES.—Recently considerable interest has been evinced in cotton growing in Lourenço Marques. The Government is giving the industry every encouragement, and a commercial company has erected a ginnery and a hydraulic



press, and has undertaken to gin, press, and deliver the cotton in Liverpool for 2d. per lb. of lint.

Much interest attaches to the projected irrigation scheme near Guija, on the Limpopo River, where some 30,000 acres are being reclaimed. It is proposed to place a large area of this land under cotton.

INHAMBANE.—On the northern bank of the Inharrimi River, fifty miles south of the town of Inhambane, between Beira and Lourenço Marques, the Anglo-East African Cotton Company has acquired 75,000 acres of land, of which it is reported that 20,000 acres are suited for cotton growing, and 1000 acres are to be planted with cotton in 1926.

AMERICA

ARGENTINE.—*Cotton - producing Possibilities.*—Given an increased supply of labour there is probably no country in the world with greater possibilities for extensive cotton production than the Argentine. Unfortunately, from a cotton-producing standpoint, there are so many competing crops that the demand on the available labour supply is already great. In the northern part of the country there are enormous areas of fertile land available, and where the climate is well adapted to cotton cultivation. Moreover, the Argentine is essentially an agricultural country, and although the development of its agricultural industry is of comparatively recent date, its progress has been even more rapid than its pastoral development.

The cultivation of cotton is a comparatively new industry, although as early as 1862-65 cotton-growing experiments were conducted on the initiative of the Cotton Supply Association of Manchester. Recently great interest has been evinced in the matter, and more especially in the Chaco and Formosa territories and the provinces of Corrientes and Misiones. In these areas cotton is grown by European planters with Indian labour, but the methods employed are rather primitive. Planting takes place from September to December, and picking begins in March and continues till June. American, Egyptian, and Peruvian varieties are grown. Unfortunately these varieties have not been kept separate and a great deal of crossing has taken place

Phenomenal yields of Egyptian cotton have been reported of as much as 500 lb. of lint per acre.

Just prior to the war of 1914 the total cotton production amounted to 2650 500-lb. bales, but that for the year 1924 amounted to 44,000 bales, while the 1925 crop is estimated at 66,000 bales. A large quantity of the crop is consumed in the local mills, and about one-half of the crop is exported to Europe, and chiefly to Spain and Liverpool.

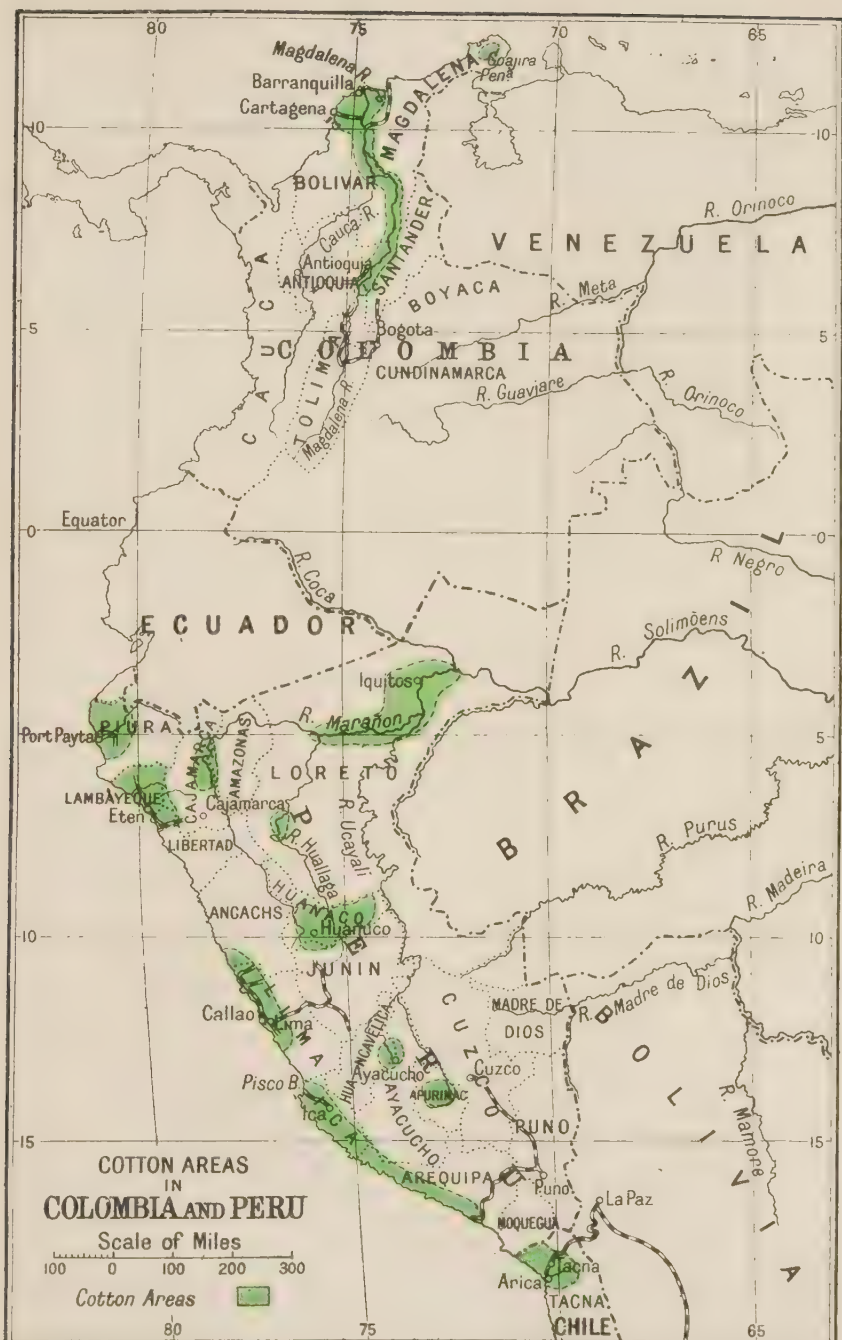
Land Tenure.—In view of the steady and growing influx of population from Europe, the question of land tenure is of interest to prospective cotton growers. In the past the Administration encouraged the allotment of enormous holdings, and difficulty was experienced by immigrants in the acquisition of small holdings. Huge estates were acquired by speculators, who left them undeveloped while waiting for the value of the land to increase. In certain cases, however, the estates were divided into small holdings and disposed of freehold at a moderate price.

A system of letting is most prevalent, usually for short periods, either at a fixed rent, on a profit-sharing system, or for a proportion of the yield for rent. The obvious objection to this procedure is that the tenant is not tied to the property, and his sole aim and object is to extract as soon as possible, and as much as possible, from the soil before the end of his tenancy.

The Land Law of 1907 was passed with the object of preventing large monopolies. It prohibits the acquisition by a single person of any portion of the national domains of a greater area than 6170 acres. Fortunately the State still has many million acres of valuable agricultural land at its disposal, and in districts that are becoming quickly populated.

It is considered that there are 157 million acres of land available for cotton growing in the Argentine, where there is ample rainfall for the crop, and some 7 million acres of land available for this crop in regions that would require irrigation.

Ginning and baling operations are chiefly carried out with American machinery, and the bales produced are similar to, though somewhat smaller than, the United States cotton bales. The principal ginnery is situated in Resistancia, Chaco, and is stated to deal with 10,000 tons of seed cotton in a season.



CHILE.—Chile is said to produce about 1000 bales of cotton per annum, but the industry shows no signs of extensive development.

COLOMBIA.—The Republic of Colombia has an estimated area of 461,600 square miles and a population of $5\frac{1}{2}$ millions. It possesses a great length of navigable rivers; still, only about one-third of the country, the north-western portion, is inhabited or in any way developed. This region is broken into deep valleys by four mountain systems which run north and south parallel with each other. The principal valley is that situated between the east and central Cordilleras, through which the navigable river Magdalena flows for 900 miles. The western part of the country is also broken up by a smaller series of parallel hill systems. The remaining two-thirds of the country is composed of an irregular parallelogram of comparatively flat country, which is traversed by innumerable tributaries of the Amazon, Putumayo, Yapura, Meta, and other rivers.

Coffee is the chief crop grown for export, while maize, beans, sugar, and rice are largely grown for local consumption.

Cotton grown for many years.—A form of *G. peruvianum* has been grown continuously from before the time the Spaniards visited the country, and it is still the principal variety grown. The staple of this cotton is about $1\frac{1}{16}$ inch long. Unfortunately its value is usually depreciated through admixture with khaki or brown-coloured lint. Egyptian and Sea Island varieties are also grown.

During recent years the area under cotton has been much extended. The crop for 1915 and 1923 was estimated at 5300 and 10,700 500-lb. bales respectively. Most of the crop is consumed by the local mills, but occasionally Colombian cotton arrives at Liverpool and also at Havre.

Cotton Areas.—Every type of climate is found in the country, from tropical on the coast to temperate and cold in the mountain ranges. The coastal zone is principally comprised of low-lying land, and the River Magdalena flows through this region. Here a high temperature prevails throughout the year, and the rainfall is fairly regular and seasonal. The soil and climate are well adapted for the cultivation of long staple cotton. It produces about 80 per

cent of the cotton grown in the whole country, and chiefly in the vicinity of Barranquilla, although a small quantity is also grown in the Goajira Peninsula.

Following the course of the Magdalena southwards, the temperature decreases as the elevation increases. Cotton is grown in the Departments of Santander and Antioquia. In these districts the soil and climate are also well suited for cotton growing, but the staple of the cotton produced is harsher and less regular than that grown in the hot zone.

A small quantity of cotton is likewise grown in sheltered plains still farther south, and, at a still higher elevation, in the Department of Cundinamarca.

Cotton Cultivation.—The land receives little preparation for planting, the surface being merely cleared. Cotton is often grown mixed with other crops such as cassava. Planting takes place in April and May, and picking from January to March. The plants usually remain in the ground for four or five years, and they receive little attention. After the picking season they are cut down to within about a foot of the ground.

Land Tenure.—There is an abundance of good, rich land available for cotton growing. A colonist may select and acquire a plot of land by the simple process of fencing and cultivating it. Having done so, he is entitled to an adjoining plot of land, of equal size to that first selected, provided a survey of his land is made, that the proper authorities are petitioned, and certain moderate fees paid.

DUTCH WEST INDIES.—Cotton is grown in Surinam (Guiana), St. Martin, and St. Eustatia.

SURINAM.—Bourbon, Peruvian, and Sea Island cottons were grown in Surinam early in the eighteenth century. In 1794 cotton equivalent to 2700 500-lb. bales was exported. The industry declined after the abolition of the slave-trade in 1863; but a revival took place later, and in 1830 cotton equivalent to 4400 500-lb. bales was exported. The industry then again declined owing to labour shortage, and exports had practically ceased by 1880.

Recently excellent samples of Sea Island cotton, with a staple of $1\frac{3}{4}$ inch, have been produced in the experimental stations, and these have been very favourably reported on both in Manchester and Rotterdam.

ST. MARTIN AND ST. EUSTATIA.—Excellent Sea Island

cotton is grown in these two islands, which compares favourably with that produced in the neighbouring British West Indies. The average annual export for the period 1911–20 was 147 500-lb. bales.

ECUADOR.—About 1000 bales of cotton are produced yearly in Ecuador, but no accurate information is available as to the production or area under the crop. The cotton resembles “Moderate Rough Peruvian”. The plant is treated as a perennial, being cut down each year and resown after four years.

GUATEMALA.—Increased attention has recently been devoted to cotton growing in Guatemala. It is grown on the Pacific slope, in the vicinity of Mazateango, and also near Zacapa, on the Atlantic slope, where a rich alluvial soil is found near the River Matagua.

The cotton produced is Peruvian type, and the whole crop is consumed by the local mills.

The development of the industry is restricted by the scarcity of labour and the restrictions on the import of coloured labour.

Weevil-eating Kelep.—In connection with the losses due to boll weevil in America, it is interesting to observe that according to Dr. Cook, of the United States Department of Agriculture, the presence of the weevil-eating kelep ant has enabled the Indians of eastern Guatemala to maintain, from very ancient times, field culture of cotton in the presence of the weevils. Moreover, there has been developed a dwarf, annual, short-season variety of *kekchi* cotton with numerous features that, in the absence of sufficient numbers of the keleps, afford material assistance in protecting the crop against the ravages of the weevil insect.

HAYTI AND SAN DOMINGO.—Reliable statistics are not available as to the amount of cotton produced in these two republics. It is chiefly low-grade Sea Island, and is generally badly handled. In 1922, Hayti cotton was valued at Havre at a price 3 points off “Middling American”.

The two countries cover an area of about 28,300 square miles, and have a population of $2\frac{3}{4}$ millions. The soil and climate are for the most part well adapted to cotton cultivation, and there are large areas of fertile land available for planting, but the unsettled state of the country is a serious handicap to the development of the industry.

The average annual exports of cotton from Hayti for the period 1911-18 amounted to 8200 500-lb. bales; those for San Domingo for the period 1911-17 amounted to 800 500-lb. bales.

MEXICO.—Cotton cultivated prior to Spanish Conquest.—Prior to the Spanish conquest of Mexico the cotton production of the native Indians was estimated at 116 million lb., and long before the arrival of the Spaniards the art of spinning and weaving had attained a high degree of proficiency. Under Spanish rule the industry declined, and in some parts of the country it was abandoned altogether. A slight fillip was given to the industry by the cotton famine during the American Civil War. Since 1882 it has received increased attention; during 1892 production was estimated at 50,000 500-lb. bales of lint; in 1925 it was estimated at 240,000 bales.

Ample Land and Labour available.—Mexico has an area of 769,000 square miles, with a population of 16 millions, mostly consisting of industrious Indian agriculturists. It is thus larger than the American cotton belt; both the soil and climate of a very large portion of this area are well adapted to cotton cultivation, and, indeed, it is grown to a certain extent throughout the country.

Along the Pacific coast the rainfall is ample for cotton growing; and in many other parts of the country, where the rainfall is inadequate, irrigation is feasible, both from numerous small rivers on the west coast and from the tributaries of the Rio Grande in the interior.

Notwithstanding the peculiarly favourable conditions that obtain, the development of the industry is checked through political unrest; but once this adverse factor is removed the cotton-producing capabilities of the country will be enormous.

Cotton-growing Districts.—The chief cotton-growing area is the Laguna district, which includes portions of the States of Durango, Coahuila, and Chihuahua; this area produces about one-half of the total crop. Statistics regarding the crop are most misleading, but it is estimated to exceed 200,000 500-lb. bales. The local mills are estimated to consume 150,000 bales, of which the Laguna district contributes 80,000 bales, the Matamoros district 20,000 bales, and the balance is supplied from the coastal States or is imported from the United States.

Long staple Egyptian and American cotton, which is largely grown under irrigation in Lower California, adjacent to the United States frontier and the irrigated cotton-growing areas of the United States, is taken by United States firms, and is also exported to Liverpool and Japan. During the 1922-23 cotton season production in this district was estimated at 70,000 bales.

In the Laguna district the climate is excessively dry, and cotton cultivation is almost entirely dependent on irrigation from the Nazas River, but the supply of water from this source is unreliable. Plans for regulating the water supply have been projected, but have not materialised owing to the unsettled state of the country.

Origin of Durango Cotton.—Planting takes place early in March, and picking begins in July. Most of the cotton grown in the Laguna district is rather inferior to Upland American. In this connection it is interesting to observe that the long staple Durango cotton, which is so largely grown in the United States and elsewhere, originally came from this region. During the 1921-22 season the average yield of lint per acre was estimated at 143 lb.

Both Egyptian and long staple American cottons are also grown under irrigation in Sonora, and in Monterrey in Nuova Leon.

Insects pests are a serious menace, for both the boll weevil and the pink boll-worm are prevalent.

TOTAL PRODUCTION OF COTTON IN MEXICO

Year.	500-lb. Bales.	Year.	500-lb. Bales.
1918	237,000	1922	151,000
1919	203,000	1923	159,000
1920	211,000	1924	239,000 *
1921	155,000	1925	240,000 *

* Estimated.

NICARAGUA.—Cotton has been grown in Nicaragua for many years, and there is promise of the industry being developed, and especially in the lowlands. The area under cotton is estimated at 5000 acres. Occasional arrivals of

Nicaraguan cotton at Liverpool have been classed as short staple.

PARAGUAY.—At one time cotton was extensively grown in Paraguay, but subsequently, and largely owing to wars, its cultivation was almost abandoned, although a certain quantity of indigenous tree cotton continued to be grown.

Of recent years the Banco Agricola del Paraguay has made efforts to revive the industry by distributing seed and guaranteeing a price for the crop. The chief centre of recent activities is the Scandinavian colony of Puerto Elisa, near Asuncion, on the Paraguay River, where an association of cotton growers has been formed for the purpose of developing the industry.

Planting is done in October and November, and the crop is harvested from January to May. American, Egyptian, and Indian varieties are being used, and these are much superior to the native cotton. The average yield is given as 200 lb. of lint per acre. Ginning operations are under the control of the Banco Agricola.

Good Prospects for Cotton.—The prospects of developing the industry seem to be most promising, and it is anticipated that cotton will shortly become an important article of export. The crop for 1922–23 was estimated at 13,440 500-lb. bales of lint, and that for 1923–24 at 26,880 bales of lint. The Paraguayan is a good agriculturist; there is an ample supply of labour, and large areas of suitable land, estimated at over 10 million acres, are available for cotton growing at a few shillings per acre. It is anticipated that the recently established Cotton Research Institute will play a useful part in developing this industry. The area planted in 1925 is estimated at 100,000 acres.

Hitherto the farmers' attention was mainly confined to tobacco, but since 1923 by the cultivation of cotton a great change has been effected in agricultural conditions. Under the old pernicious system by which his prospective crop of tobacco was mortgaged, the farmer was virtually in the hands of the produce merchant or the storekeeper. The cotton crop has liberated him from these conditions and a demand has arisen for modern ploughs and other agricultural implements, including motor tractors, in the desire to get as much land under cotton as possible.

The exports of cotton from Paraguay in recent years have been as follows :

Year.	Exports (Bales of 500 lb.).	Year.	Exports (Bales of 500 lb.).
1918	35	1922	1688
1919	138	1923	4400
1920	715	1924	8800
1921	472		

PERU.—*Ancient Cotton Industry*.—Cotton has been grown and manufactured in Peru from prehistoric times ; it is reported that exquisitely coloured cotton cloths have been discovered in the ancient tombs of the imperial Incas. When the country was conquered by the Spaniards, there existed a flourishing cotton industry, and the Spaniards found the natives clothed in cotton garments. As in Mexico and several other countries, the Spaniards neglected, and even discouraged, cotton cultivation. After the declaration of Peru's independence in 1821, the industry showed considerable decline, but it was resuscitated by the conditions brought about by the American Civil War.

In 1862 Peru exported 680 500-lb. bales of cotton to Liverpool ; three years later the exports to this centre increased to more than 8000 bales. The industry again languished after the cessation of hostilities until 1885. From that year until 1892 the annual exports amounted to about 12,000 bales. In 1899 they had increased to 25,000 bales. The average annual production for the period 1912 to 1921 was 126,300 bales ; in 1923 it exceeded 237,000 bales.

Climate and Topography.—Peru comprises an area of 520,000 square miles, and has a population of more than $3\frac{1}{2}$ millions. The climate is practically rainless—except in the north, where torrential rains sometimes fall in the summer. During the summer, fogs occur which occasionally result in rain, but the precipitation is of no importance from an agricultural point of view. Cotton cultivation is therefore entirely dependent on irrigation.

The temperature is moderated by Humboldt's current and is fairly uniform throughout the year. The coast provinces have a mean average temperature of 68° F.—that of

the hottest months is 84° ; it is thus lower than other countries in South America that are situated in a similar latitude.

The country is traversed throughout by the Andes, which run parallel to the Pacific coast. The configuration of the coast region is peculiar; it consists of arid sand-hills, intersected by numerous valleys running from the Andes to the sea.

Cotton-growing Areas.—The principal cotton-growing region is found on the coast, where each valley is a river bed and is enriched by deep alluvial deposits. During the summer months the volume of the rivers is increased by the melting mountain snow, and, as the valleys are fairly steep, irrigation is rendered comparatively simple. Elaborate irrigation systems distribute the river waters over the cultivated areas, which are, for a large part, on the original irrigation canals of the Incas.

Some of the cotton estates cover a considerable area, but they vary in size from 500 to 5000 acres. They are owned by Peruvians and are worked by native Indians. In certain cases, however, it has proved more satisfactory to sublet small holdings on a profit-sharing basis.

Many of the valleys are near the coast, where railway communications are fairly good, so that transport presents little difficulty. On the islands off the coast there are large deposits of guano, which can be obtained by the simple process of digging, and at a small cost, and it is thus largely used for maintaining the fertility of the soil. Otherwise the cultural methods employed are rather primitive.

Decline of Rubber Industry favourable for Cotton.—The decline in the rubber industry has encouraged cotton to be grown in the Amazon basin district of Peru, of which the centre is Iquitos. In 1919, 4480 bales of cotton were exported down the Amazon from this Transandine region, where there are enormous areas of fertile land available for cotton growing. Their development is, however, mainly dependent on the provision of road transport, irrigation, and labour. In the coast region there is a prospect of a very considerable development of the industry if the existing irrigation systems are improved and extended.

Varieties of Cotton grown.—Formerly some 65 per cent of

the crop consisted of Smooth Peruvian. This is probably a form of *G. vitifolium*; it is the chief indigenous cotton of north Peru, and is still grown to a considerable extent. It is usually grown as a biennial, but is pruned down after the first year. It yields 500 lb. of seed cotton per acre in the first year and 350 lb. in the second. It has a strong, good coloured staple of $1\frac{1}{4}$ inch, and sells at a premium of about 70 points on "American Middling". Its ginning out-turn is 31 per cent of lint.

"Rough Peruvian", *G. peruvianum*, is mostly grown in the northern valleys, where the heat is greater and the rainfall is heavier than on the rest of the coast. The methods of cultivating this variety are rather peculiar. The land is divided into plots measuring 274 feet square. In these twelve furrows are opened 33 inches wide and of a similar depth, and about 22 feet apart. The cotton is sown after the flood in summer, February and March. The seed is sown on both sides of the furrows, the stands being 20 feet apart. The intervening spaces are planted with maize, melons, and similar crops. The cotton plants remain in the ground for from four to six years, and during this period they receive little attention besides weeding, pruning, and irrigation. Picking takes place throughout the year, but the principal harvest seasons are June to October and December to March.

The plants grow to a height of 9 feet. The yield varies with the age of the plant, the best being obtained at the second and the third year. The average yield is said to be 320 lb. of seed cotton per acre, and the ginning out-turn 35 per cent of lint. The lint is harsh and crinkly, $1\frac{1}{4}$ to $1\frac{1}{2}$ inch long, and is specially prized for spinning with wool.

Tanguis cotton, which is named after its discoverer, is reputed to be a hybrid of Smooth and Rough Peruvian. It has rapidly gained in favour, and is reported to constitute the major portion of the crop. It is said to yield better than its parents, and to be resistant to the wilt disease. The lint is white and its woolly consistency lends itself to admixture with wool for manufacturing purposes. •

Sea Island cotton is grown in small quantities near the coast, while Egyptian Afifi cotton is produced superior even to that produced in Egypt.

Handling the Crop.—Most of the large estates operate their

own ginning equipment, and they gin and press the cotton of small planters in exchange for the seed. At some of the ginneries the seed is crushed, and the resultant oil is consumed in the local soap industry. The Peruvian cotton bale usually weighs 250 lb. Most of the crop is exported, but in the Apurimac district, cotton is almost exclusively grown to meet the requirements of a local spinning mill, which produces about 6400 yards of cloth per day.

Pests.—The crop does not appear to be seriously affected by pests and diseases. The most troublesome insect pests are cotton worms, stainers, and the white louse, *Hemichionaspis minor*, Maskill.

COTTON PRODUCTION IN PERU

Year.	500-lb. bales.	Year.	500-lb. bales.
1918	136,000	1922	179,000
1919	183,000	1923	237,000
1920	160,000	1924	250,000 *
1921	192,000	1925	250,000 *

* Estimated.

PORTO RICO.—About 3000 acres are under Sea Island cotton cultivation in Porto Rico and the produce is exported to the United States.

SAN SALVADOR.—According to a recent report by Consul W. J. McCaffarty, cotton has been grown on a commercial scale in San Salvador for the first time (1924–25), and the crop is estimated at from 8900 to 9400 bales of 478 lb. net. The area under cultivation is estimated at 33,000 acres. The variety most generally grown is Acala, which has a staple of $1\frac{1}{8}$ to $1\frac{1}{4}$ inch. Planting takes place from July to September and picking commences in November.

URUGUAY.—Uruguay is said to produce as much as 10,000 bales of cotton, and there appear to be prospects of still further development.

VENEZUELA.—Cotton has been grown in Venezuela since the American Civil War. The average annual production is about 31,500 500-lb. bales, and about one-third of this is consumed in the local mills.

The soil and climate appear to be better adapted to the

cultivation of Upland cotton than Sea Island and Egyptian kinds.

The country covers an area of 364,000 square miles, and has a population of nearly 3 millions.

Cotton is chiefly grown in the coast States, but there are enormous areas that are well adapted to its cultivation all over the country, and if properly exploited it would probably soon become one of the most important cotton-producing centres in the Western Hemisphere.

AUSTRALASIA

NEW CALEDONIA.—Cotton has been grown in this island for many years, but since the outbreak of disease in coffee, which is the chief competing crop, cotton-growing promises to become the principal agricultural industry. The variety of cotton grown is a form of *G. peruvianum*, which produces a staple of $1\frac{1}{16}$ to $1\frac{3}{16}$ inch. In 1920 the crop amounted to 440 500-lb. bales. The yields are high, and are reported to average about 400 lb. of lint per acre. The whole of the crop, as well as that of New Hebrides, is ginned and manufactured in the island.

NEW HEBRIDES.—The variety of cotton grown in New Hebrides is similar to that grown in New Caledonia. For the period 1914 to 1921 the average annual production of cotton was 2050 500-lb. bales.

SOCIETY ISLES.—At one time considerable quantities of cotton were produced in these islands. In 1866 the cotton crop of Tahiti alone was valued at £100,000. The industry steadily declined until, in 1903, production ceased altogether. Since that date attempts have been made to foster the cultivation of both Sea Island and Egyptian cotton. The competition of more lucrative crops and labour shortage have seriously handicapped these operations, although both in 1909 and 1910 over 300 bales were produced.

NEW GUINEA.—Good samples of Sea Island and American Upland cotton have been produced in New Guinea. As the Papuans are good agriculturists, and large areas of land suitable for cotton cultivation are available, and land tenure is easily obtained, it may be possible to extend the relatively small area already under cultivation.

CHAPTER XI

THE CULTIVATION OF COTTON

Climatic considerations—Mean monthly temperatures F. in the United States cotton belt—Rainfall requirements—Soils—Soil maintenance and improvement—Farmyard manure—Green manuring—Green manuring supplemented by commercial fertilisers—Commercial fertilisers—Advantages of burying cotton plants—Liming—The different forms of lime—Lime in the soil—Lime and soil acidity—The physical effects of lime—Lime and soil bacteria—Caution in lime application—Form in which to apply lime—Method and time of application—Rate of application—Testing for soil acidity—Soil erosion—Hill-side ditches—Terracing—Crop rotation—Fallowing—Preparation of the land for cotton planting—Cotton seed for planting—Mixture of seed in ginneries—Causes of seed “running out”—Storage of seed—Inferior quality of commercial seed—Delinting seed for planting—Germination tests—Naming of varieties—Sowing cotton seed—Treatment of fuzzy seed—Method of planting rare seed—Thinning the plants—Cultivation after planting—Single stalk cotton culture—Cotton culture under irrigation—Choice of land—Canals and ditches—Surface levelling—Water application—Water conservation—“Free water” in the soil—Quantity of water to apply—Drainage—Cultivation of irrigated land—Picking cotton.

IN the preceding pages an attempt has been made briefly to describe the extremely varied conditions under which different kinds of cotton are grown in various parts of the world. A study of these conditions will make it manifest that it is quite impossible dogmatically to lay down a correct method of cotton culture, even as regards one kind of cotton, that would be universally applicable. There are, however, certain general principles which must be observed in the cultivation of this product, if the best results are to be obtained. It is of the first importance to provide, as far as possible, a favourable environment for the crop, by creating healthy conditions as to soil and climate, in order to promote a naturally resistant constitution to withstand the manifold diseases and pests to which the plant is subject.

Climatic Considerations.—Climate is the chief limiting factor in cotton cultivation, for it is essentially a tropical or sub-tropical plant, and frost is inimical to its growth. Moreover, abrupt changes of temperature, and lack of soil moisture during the growing season, check the plant's development and are conducive to bud and boll shedding.

The limit of cotton cultivation in the Northern Hemisphere is found at $42^{\circ} 30'$, and in the Southern Hemisphere at 25° .

Along the northern boundary of the United States cotton belt there is a frostless season of about 200 days' duration, while in the southern portion of this belt there is a frostless season of about 260 days. The successful cultivation of cotton is not only governed by the length of the frostless period, but by the degree of temperature prevailing, soil and atmospheric moisture, and the type of cotton under treatment. Under optimum conditions certain short staple varieties may produce a profitable crop in a growing season of five months, while some long staple varieties and tree cottons may require a growing season of nine months under similar conditions.

The period from the date of planting to the commencement of the harvest in various countries is approximately as follows:—India, 107 days; United States, 122 days; Egypt, 185 days; West Indies, Sea Island cotton, 200 days.

Other conditions being satisfactory the most favourable temperature for the optimum growth of cotton is approximately 90° F., with a correspondingly warm night. The average summer temperature in the northern section of the United States cotton belt is 77° F., and this is probably the lowest summer temperature at which cotton can be successfully grown; 80° – 85° F. is the average summer temperature in the southern portion of this belt, and 95° F. is the average summer temperature in the Imperial Valley, California.

That a considerable range of temperature is permissible is well illustrated by the subjoined table showing the mean temperatures that prevail during the growing season in different sections of the United States cotton-growing areas.

MEAN MONTHLY TEMPERATURES, F., IN THE UNITED STATES COTTON BELT.

	April.	May.	June.	July.	Aug.	Sept.	Oct.	Mean.
North .	61	69.2	76.7	79.5	77.3	71.3	61.8	70
Middle .	63.2	70.8	77.9	80.9	79.6	74.4	65.2	73.1
South .	69.7	75.4	81.3	83.3	82.1	78.2	70.3	77.2

MEAN MAXIMUM TEMPERATURES, F., IN THE UNITED STATES COTTON BELT.

	April.	May.	June.	July.	Aug.	Sept.	Oct.	Mean.
North .	72.6	80.1	87.2	89.9	87	81.3	72	81.4
Middle .	72	79.8	86.3	88.8	87.3	82.8	73.7	81.5
South .	78	83.6	89	91.1	90	86	78.8	85.2

MEAN MINIMUM TEMPERATURES, F., IN THE UNITED STATES COTTON BELT.

	April.	May.	June.	July.	Aug.	Sept.	Oct.	Mean.
North .	49.8	57.5	65.4	69	67.3	61.2	50.9	60.2
Middle .	54.8	61.9	69.1	72.2	71.7	67	56.6	64.8
South .	61.3	67.2	73.6	75.6	74.2	70.5	62.9	69.3

MEAN MAXIMUM TEMPERATURES, F., IN ARIZONA AND CALIFORNIA,
where long staple cotton is grown under irrigation.

March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Mean.
75.3	82.9	89.4	99.7	102.2	101.9	91.5	85.2	91

MEAN MINIMUM TEMPERATURES, F., IN ARIZONA AND CALIFORNIA,
where long staple cotton is grown under irrigation.

March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Mean.
44.4	49.1	54.2	62.9	70.3	68.9	62.6	51.1	57.9

Rainfall Requirements.—For rain-grown cotton the quantity of the rainfall is not of so much importance as the nature of its distribution, and the soil's capacity to absorb the moisture and retain it for effective use. It is generally recognised that a well-distributed rainfall of from 20 to 25 inches is sufficient for cotton production. Provided the precipitation is favourably distributed throughout the growing season, a rainfall as low as 15 inches may be sufficient to produce an average crop of short staple cotton, while under similar conditions a rainfall of 20 inches may yield a good crop. The growing season of long staple cottons, being about two months longer, they require a correspondingly increased rainfall. In many parts of the United States cotton belt the average precipitation ranges from 30 to 50 inches; in Texas

and Western Oklahoma it is only 23 inches, while in Northern Carolina and Southern Mississippi it is 55 inches and 60 inches respectively.

Spring rainfall ranges from 6 inches in Western Texas to 16 inches in Arkansas and Southern Mississippi. Summer rainfall ranges from 8 inches in Central Texas to 20 inches in Southern Mississippi, and the eastern part of North and South Carolina. Autumn is the driest part of the year in most of the cotton belt, and less than 10 inches of rain falls. February and November are the wettest months in the Mississippi Valley States, Alabama, and Georgia; August is the wettest month in the Carolinas, and May in Texas and Oklahoma.

The rainfall requirements of American cotton is indicated in the subjoined schedule of the average rainfall and average number of rainy days prevailing, during the growing season, in different sections of the United States cotton belt.

Sections.	May.		June.		July.		August.		September.	
	Rainfall. Inches.	Number of Rainy Days.	Rainfall. Inches.	Number of Rainy days.	Rainfall. Inches.	Number of Rainy Days.	Rainfall. Inches.	Number of Rainy Days.	Rainfall. Inches.	Number of Rainy Days.
Northern	3.71	10	3.77	10.4	3.83	10	3.87	10.4	3.14	8.3
Middle	4.48	9	4.60	10.5	4.87	10.8	4.74	10.6	4.43	8.0
Southern	3.74	8	5.18	10.3	4.91	11.2	5.55	11.2	5.71	10.7

During the sowing and seedling stage light and frequent showers are most beneficial. An undue amount of moisture in the soil at this period, more especially if this is concurrent with a low temperature, is conducive to seed rotting, damping-off of seedlings, and the development of surface roots to the disadvantage of the lower root system, which causes the plants to wilt and the bolls and leaves to be shed if a spell of dry weather occurs at a later period.

Excessive soil moisture, later on in the plant's development, promotes excessive vegetative growth at the expense of boll production, and it likewise interferes with cultural operations, and encourages weed growth. On the other hand, drought causes the plants to be stunted, to mature early, and consequently reduces the yield. The most favourable rainfall, at this period, is that of the thunderstorm type,

alternating with several days of bright warm weather. Abundance of sunshine is of great importance during the flowering period.

As the crop matures, and the bolls commence to open, less moisture is necessary, for wet weather retards crop development, and later interferes with harvesting, and damages the lint in the open bolls. A lower temperature is beneficial at this period, for it checks vegetative growth and encourages boll production.

Briefly summarised, ideal growth conditions are, a steadily rising temperature just prior to planting until boll maturity, good rains for the planting season to ensure satisfactory germination, followed by a period of moderately dry weather to prevent seed rot, then an increased volume of rain till just prior to plant maturity, and dry weather for the harvest.

Soils.—That the cotton plant is by no means fastidious, as regards its soil requirements, is well demonstrated by the great variety of different soils on which cotton is successfully produced in the various countries mentioned in the preceding pages of this book. A medium sandy loam is generally considered to be the ideal soil for cotton cultivation; but cotton may be grown on sandy soils, provided they contain a sufficient quantity of humus and that the subsoil is not too porous. It may also be successfully grown on clayey soils, but in this case wet seasons are likely to cause the plants to grow rank, and the yield to be small and the fibre weak. Similar results may be obtained when it is grown on very rich soils. It is consequently inadvisable to attempt to grow cotton on newly cleared land, until one or more other crops have been grown on it.

As long ago as 1834 Royle pointed out that the chief faults in India had been the over-production of vegetative organs at the expense of those of fructification. In the fertile soils and forcing climate of West Africa, the farmer suppresses the vegetative organs of the plants, by growing the robust native cottons in dense clumps. Similar effects are produced in India, and other countries, by growing along with cotton crops that mature early and are harvested while the cotton is still young.

Shallow soils should be avoided, for the cotton plant has

a long tap-root, by means of which it draws supplies of plant food and moisture from the lower soil layers.

Alkaline soils are not to be recommended for cotton cultivation, although a small amount of alkali in the soil is not seriously injurious to cotton.

Generally speaking any soil, on which ordinary field crops can be successfully grown, will produce good crops of cotton.

In the United States cotton belt cotton is grown on nearly every type of soil, provided it is well drained. In normal seasons the most productive soils are the dark-coloured clays, especially those that are rich in lime, of the black prairies of Alabama, Mississippi, and Texas, and the black, red, and brown, well-drained river bottom lands, similar to those obtaining in Mississippi, Tennessee, and Arkansas. The sandy loams of the coastal plain, and the red subsoil land of Piedmont likewise produce high yields when fertilisers are applied to them; and this proviso also applies to much light, sandy soil in the belt.

Soil Maintenance and Improvement.—In the tropics and sub-tropics, the processes by which the insoluble constituents of soils are rendered available for the use of crops are accelerated. Organic matter decays more rapidly, so that the humus content of the soil is quickly depleted, unless suitable measures are adopted to supply new stores. In the absence of adequate supplies of animal manure, it is necessary to determine the cheapest and most effective manner of employing green crops for the purpose of maintaining the soil's fertility. It consequently follows that the application of commercial fertilisers needs to be supplemented with other important methods of soil maintenance. It is true that the stronger and more fertile soils suffer less rapidly when this is neglected than the lighter types of soils. In other words, the use of commercial fertilisers must be supplemented by the addition of organic matter in the form of animal manure or green crops, or a combination of these for the provision of humus.

The supply of humus is one of the most important factors in soil maintenance and improvement, for crop yields are largely influenced by the quantity of organic matter present in the soil. Its presence increases bacterial activity, which

is so essential to crop production ; it enables water to be absorbed and retained more readily, and lessens the danger from erosion. Further, the soil is rendered more friable and easy to work, and it is less likely to become hard or form a crust after rain. In heavy soils, benefit accrues by the separation of the soil particles, which makes them more permeable to air and moisture, while in the case of light soils the moisture-holding capacity is increased. Moreover, it is the chief source of nitrogen, which is one of the most expensive fertilisers to purchase. Experiments have shown that, in the case of light soils, it is possible, by increasing the organic matter in the soil by 0.5 per cent, to increase the amount of nitrogen in the soil by as much as 245 lb. per acre.

Crop residues constitute a very valuable source of organic matter, and due regard must be paid to the selection of rotation crops which leave much plant material behind after harvest.

The maintenance of live-stock on the farm is of importance, both for the manure obtained from the stalls and the benefits that accrue from ploughing up land on which cattle have been pastured after the removal of the crop, for such land is enriched both by vegetable matter and the manure of the animals pastured.

The matter of soil improvement should be considered not only as an agricultural problem but as an economic problem as well, for the enterprise is obviously unsuccessful unless the increase in crop yield either immediately or in the near future justifies the expenditure involved.

Cotton is not a very soil-exhausting crop. In deep fertile lands in the West Indies it has been demonstrated that cotton can be grown for seven consecutive seasons without any manifestation of any definite difference between manured and unmanured plots. This circumstance does not of course imply that fertilisers are not necessary.

The conditions as regards soil and climate, in tropical and sub-tropical regions, are subject to such extreme variations that it is quite impracticable to lay down rules for manuring that would be generally applicable. Regard must be always had for the circumstance that, as already stated, the insoluble constituents of plant food in the soil are rendered

more rapidly available for the use of the crop in these regions, and that all organic matters that contain nitrogen are utilised by the crop more readily than is the case in colder regions.

Moreover, the stores of phosphoric acid and nitrogen in the soil are more available in warm countries, for the higher temperature of the soil-water, and the larger supply of carbon dioxide in the soil, result in an accelerated weathering of the soil's mineral constituents. Lighter applications of fertilisers are therefore effective in proportion to the quantity of plant food which the crop withdraws from the soil. Certainly so far as cotton is concerned, fertiliser application may be reduced by about one-half of that ordinarily used for most crops in temperate countries.

Farmyard Manure.—Farmyard manure, when it is produced on the farm, is not only cheaper, more effective, and lasting, than commercial fertilisers, but it is invaluable in its effects on the physical condition of the soil. Cotton receives greater fertilising benefit from farmyard manure when it is applied to the previous crop in the rotation than from a direct application in the same season that cotton is grown. The Indian *ryot* has long recognised the advantage of this procedure, and moreover, he declares that the direct supply of farmyard manure to cotton “burns the plants.”

Green Manuring.—The advantages attaching to the growing of leguminous crops, and incorporating them in the soil, are now universally appreciated. This practice must not be expected thoroughly to renovate exhausted soils, as although more nitrogen is returned to the soil, owing to the property that legumes possess of absorbing free nitrogen from the atmosphere, the amount of phosphoric acid and potash returned to the soil is that which the plants have extracted from it. But as the green material decays in the soil, acids are formed which aid in the dissolution of some of the unavailable plant foods in the soil.

It is important that green manuring crops be thoroughly ploughed in the land sufficiently early for them to decay before cotton seed is planted, for the germination of the seed is affected if it is sown over a layer of raw green dressing; probably owing to the effect of the carbon dioxide given off by the plants.

The cow-pea, *Vigna catieng*, is one of the most largely used green manuring crops ; it will thrive on poorer lands, and give better results under such conditions, than most other crops of this nature. Excellent results may be obtained by sowing cow-peas in maize, at the time of the last cultivation of the latter, and ploughing them both into the land after the maize crop has been harvested.

In the United States crimson clover has proved valuable for the purpose. It is sown in August and September, or with maize at the last cultivation in the late summer. Buckwheat is sometimes sown with crimson clover in July ; the buckwheat is allowed to mature, and the grain is harvested, while the crimson clover remains. In both cases the clover occupies the land during the winter, serving as a cover crop and protecting the soil from washing and leaching. Crimson clover requires a richer soil than cow-peas, so that on poor land an application of from 200 lb. to 300 lb. of acid phosphate is advantageous in giving the clover a start.

The hairy vetch is another green manuring crop in use in the United States. It is sown, mixed with wheat or rye in the autumn, at the rate of 30 lb. of vetch to a bushel of grain. It is more hardy than crimson clover, and may be sown later in the season.

On heavy soils red clover is sown in the spring on small grain and it matures the following year.

Other crops used in cotton-growing for green manuring are : ground nut, *Arachis hypogea* ; soy bean, *Glycine hispida* ; Lima bean, *Phaseolus lunatus* ; woolly pyrol, *Phaseolus Mungo* ; sword bean, *Canavalia gladiata* ; Lablab bean, *Dolichos Lablab* ; and Bengal bean, *Stizolobium* sp.

Green Manuring supplemented by Commercial Fertilisers.—An excellent example of the good results attending green manuring, supplemented with judicious fertiliser application to “ worn out ” soil, is given in Farmer’s Bulletin, No. 924, United States Department of Agriculture, with regard to a farm in Virginia. The farm in question is situated on the typical sandy land of the Coastal Plain, and it had been continuously cropped in maize and cotton until it had become so unproductive that tenants refused to cultivate it. It is important to emphasise the circumstance that this condition of affairs had been brought about by injudicious

methods of crop farming, for fertilisers had been liberally supplied both to the cotton and to the maize crops.

The ownership of the farm changed and, with a limited amount of capital, the new owner immediately instituted rational methods of soil improvement. In the spring some of the fields were planted with cow-peas, and were given an application of 250 lb. of acid phosphate per acre. In cases where the peas made good growth, they were cut for hay, but where the growth was poor, they were left standing. In the following spring these fields were planted with cotton, and an application of 200 lb. of a 2-8-3 fertiliser, containing 2 per cent ammonia, 8 per cent phosphoric acid, and 3 per cent potash per acre was given. After the first cotton picking, crimson clover was sown in the cotton. As a result, the yield of cotton increased from less than 100 lb. of lint per acre to 166 lb. of lint per acre.

A two-year rotation was developed from the operations of the first year, *i.e.* (1) Cotton with crimson clover; (2) maize with cow-peas. The crimson clover was sown either at the last cultivation of the cotton, or immediately after the first cotton picking, depending on the suitability of the soil as regards moisture. The cow-peas were sown in the maize at the last cultivation of the maize. Sufficient cow-peas were picked for seed purposes each year, and occasionally some for sale as well. In the fourth year of this rotation the yield of cotton lint was at the rate of 570 lb. per acre.

Commercial Fertilisers.—In connection with the use of commercial fertilisers, due consideration must be paid to what has been said above in regard to the importance of maintaining and increasing the amount of organic matter in the soil. In many parts of the American cotton belt farmers now thoroughly appreciate that the best results are only obtained from the use of commercial fertilisers when a comparatively high percentage of organic matter is maintained in the soil, and when fertilisers are applied in accordance with the needs of the soil rather than the requirements of the individual crop. Generally speaking, provided sufficient attention is devoted to the maintenance of the nitrogen supply in the soil, the use of a fertiliser containing both phosphoric acid and potash will give the most satisfactory results. Moreover, in many cases it has been found most

effective to apply the fertiliser to a green crop which is grown for soil improvement purposes, for the effects of the fertiliser are more lasting than if it is applied when the land is being prepared for the cotton crop.

When it is found necessary to apply an artificial nitrogenous fertiliser, nitrate of soda or sulphate of ammonia, used at the rate of 100 lb. of the former or 80 lb. of the latter per acre, may generally be depended upon to give the desired results.

Phosphorus is the fertiliser that is usually most required in cotton soils. It is customary to supply it in the form of superphosphate of lime, at the rate of from 200 lb. to 500 lb. per acre, in accordance with the soil's requirements. This fertiliser not only checks coarse growth, but it encourages the ripening of the bolls and improves the quality of the lint.

At the Rustenburg Experiment Station, South Africa, it has been shown that, with a rotation of maize, tobacco, cotton and green manuring, an application of 200 lb. per acre of acid phosphate, once in the rotation, gave a marked increase in the yield of cotton and the other rotation crops, as well as a good profit.

Potassium is not generally so necessary as nitrogen and phosphorus, and it has comparatively little value when it is applied alone. In conjunction with other fertilisers, it is usually applied in the form of kainit or muriate potash, at the rate of from 50 lb. to 200 lb. per acre.

In the American cotton belt a formula which is recognised in connection with fertiliser application is as follows: 8 per cent available phosphoric acid, 1.65 per cent nitrogen (equivalent to 2 per cent ammonia), and 2 per cent potash. The following is an example of a compound that contains constituents complying with this formula: 500 lb. cotton seed meal containing 6.2 per cent nitrogen, 1.5 per cent potash and 2.5 per cent phosphoric acid; 340 lb. kainit containing 12 per cent potash; and 1110 lb. acid phosphate containing 14.5 per cent available phosphoric acid. This compound is applied at the rate of from 100 lb. to 200 lb. per acre.

In many parts of the belt fertiliser purchase entails the greatest cash outlay in connection with the production of cotton, and, next to labour, it is the most costly factor in cotton production.

Experiments conducted in the United States have shown that the germination of cotton seed is frequently inhibited by the presence of fertilisers mixed with the soil in which the seed is planted, and that the effect is greater when the fertiliser is in direct contact with the seed, and especially in the case of the more soluble mineral fertilisers. This circumstance is apparently due to a retarding influence upon the osmotic absorption of water from the soil by the seed in the case of the soluble mineral fertilisers, and in the case of organic fertilisers, such as cotton seed meal, to the stimulation of the growth of fungi that are injurious to the root system of the young seedlings.

Advantages of Burying Cotton Plants.—It is a common practice to cut down the cotton plants after the harvest, and then to burn them. This involves a loss to the soil of a considerable amount of valuable organic material and fertilising substances, and its continued practice tends to soil impoverishment unless the wastage is made good in some other way. It is of course sometimes desirable to burn the cotton plants on account of the prevalence of pests which cannot be effectively destroyed by burying the plants.

Experiments conducted in the West Indies have shown that the weight of the cotton plants per acre, after the crop has been reaped, for unmanured and pen-manured land, is approximately 6140 lb. and 9780 lb. respectively. The chief fertilising constituents contained in the plants were found to be as follows : nitrogen, 2·16 per cent ; phosphoric acid, 1·4 per cent (on air dry material) ; and potash, 2·35 per cent. It is estimated that the quantity of plant-food constituents that are returned to the soil per acre when the plants are buried is as follows : nitrogen, 171·9 lb. ; phosphoric acid, 111·44 lb. ; and potash, 187·1 lb. The actual quantity of plant-food constituents that is annually removed per acre from the soil, from land yielding at the rate of 1000 lb. of seed cotton per acre, need therefore only be : nitrogen, 26·32 lb. ; phosphorus, 12·67 lb. ; and potash, 11·96 lb.

It is customary, in cases where the cotton plants have grown too large for them to be effectively ploughed underground, to employ plant-chopping machines to cut up the cotton plants into small pieces prior to ploughing operations.

Liming.—The practice of applying lime to soils, for the purpose of increasing the yield of crops, dates back more than 3000 years. In view of the fact that lime is deficient in many tropical soils, the subject is of particular interest to cotton-growers. It involves the application to the soil of the element calcium in one of two forms, *i.e.* calcium carbonate, which is more commonly known as carbonate of lime, or calcium oxide, which is the ordinary burned lime of commerce. Also included under the term lime are carbonate of magnesium mixed with carbonate of lime, as found in dolomitic or magnesium limestone, and the mixed oxides resulting from burning such limestones.

The Different Forms of Lime.—The commonest forms in which carbonate of lime occur in nature are, ordinary limestone and marl; less common forms are chalk, marble, coral, oyster, and similar shells. When properly prepared all these forms are suitable for agricultural use.

Limestone varies in colour from a light grey to black, in some cases with shades of reddish-brown. It is distinguishable from other rocks of like appearance by the circumstance that it effervesces or gives off bubbles of gas, when a dilute acid is applied to it. Limestone requires to be ground or pulverised before it can be directly used in agricultural practice. Its average content of carbonate of lime is about 82 per cent; the impurities present have no agricultural importance.

In appearance, dolomitic or magnesium limestone often resembles ordinary limestone. Frequently, it does not effervesce on the application of dilute acid unless it is warmed. For agricultural purposes, its value is about equal to that of ordinary limestone.

Marl generally occurs as a deposit under other material, or in the beds of streams or lakes; it is more variable as regards its content of carbonate of lime than limestone, and its impurities are generally clay or silty matter. Usually it is in a more or less finely divided condition, and it then has an advantage over limestone, in that it may not require grinding for agricultural use.

Coral consists of the skeleton remains of marine organisms, and has about the same content of carbonate of lime as limestone. Coral deposits that have been exposed and weathered

become soft and friable, whereas those below the surface are hard and require to be ground. Beach sands, in the neighbourhood of coral formations, are often largely comprised of coral fragments and small shells, which also have a value for liming.

Oyster and other shells contain as much as 95 per cent of carbonate of lime, and, when they are finely ground or burned, constitute a valuable supply of lime for agricultural purposes.

Oxide of lime or calcium oxide is derived from some form of carbonate of lime by heating or burning. By this process carbonic acid is driven off, but as nothing else is removed, the purity of the resultant product is dependent upon the quality of the form of carbonate of lime treated. Limestone is the primary source of calcium oxide. Under treatment, the limestone retains to a great extent the lump form in which it is placed in the kiln.

When lump lime is treated with the proper quantity of water, chemical combination takes place, heat is generated, and the lumps fall to a dry white powder, which is known as slaked or hydrated lime.

Wood ashes contain potassium carbonate and calcium carbonate in considerable quantities. They have a strong alkaline reaction, and have the property of neutralising soil acidity in proportion to their content of oxides or carbonates. Usually their principal agricultural value lies more in their content of potash than of lime.

Lime in the Soil.—All soils contain lime in one form or another; besides the carbonate already referred to, it may exist as the sulphate known as gypsum, or as various forms of complex compounds termed silicates. The latter are very slightly soluble and supply lime to the soil by slow decomposition. Lime also occurs combined with the organic constituents known as humus, where it is usually slightly soluble, and is held in a condition to be utilised by micro-organisms. As carbonate of lime is more soluble in soil water than are the lime silicates, it is more readily leached from the soil and lost in the drainage water.

Nearly all crops demand the presence of lime in the soil in which they are grown, and it has often been too generally assumed that soils contain all the lime needed by the plant

in building up its tissues. This may not always be the case, as there is considerable evidence to show that some of the beneficial effects attending liming may be due to the supply of lime needed by the plant. Quite apart from supplying this need, however, the application of lime often brings about changes in the soil that render it more suitable for the growth of crops.

Lime and Soil Acidity.—One of the most beneficial effects of liming is the correction of soil acidity. Among the products of the decay of organic matter in the soil organic acids are formed. In properly drained and well-cultivated soils this acidity may be neutralised through the acid combining with the mineral constituents of the soil. The accumulation of these acids to an injurious extent may be prevented by drainage or by the free access of air. Unless the neutralisation is effected, and acids accumulate, the soil becomes sour. Compounds of an acid nature are also derived from complex silicates that comprise a large proportion of the rocks from which soils are formed, and lime is required to neutralise this acidity.

The Physical Effects of Lime.—Lime improves the physical condition of both heavy and light soils. Heavy soils, which comprise a large proportion of clay or silt, exhibit a tendency to become compacted owing to the close association of the fine soil particles, thus preventing the free circulation of air and water which is so essential for healthy plant-growth. Lime favours the flocculation of the soil particles and the conversion of the soil into a more crumbly consistency, with the consequent improvement of aeration and drainage conditions. On the other hand, with certain sandy soils lime exerts a binding effect. Applications of lime also aid in rendering other minerals, especially potash, more soluble, and therefore more readily available for the use of the growing crop.

Lime and Soil Bacteria.—The decomposition of organic matter in the soil is stimulated by lime, and it is this decomposition which furnishes the food necessary for the development of the bacteria that render nitrogen in the soil available to plants. The nitrogen-fixing organisms that increase the stock of nitrogen in the soil are also benefited by liming. It is probable that its beneficial effects on the decomposition of

organic matter in the soil are the most general and most important of all.

Caution in Lime Application.—A considerable amount of circumspection must be observed in the application of lime to soils, for all the soils that require it need not necessarily require it for the same reason. In view of its effects on organic matter, it is inadvisable to apply it to soils deficient in organic matter, especially in hot moist climates, unless measures are also adopted to maintain or increase the supply of this material.

Poorly drained soils that are lacking in lime will be benefited by heavy dressings of lime, whereas a compacted soil may be benefited by a comparatively light dressing. The decomposition of organic matter is stimulated by quite small dressings.

In pure water carbonate of lime is almost insoluble, but in soil moisture, which holds carbonic acid gas in solution, it is soluble in proportion to the quantity of carbonic acid gas in solution.

Regarding the form in which carbonate of lime should be applied to the soil, it should be observed that, so far as the immediate effect of carbonate of lime is concerned, its value depends on the extent to which it is pulverised; because it is only through solution that it can be distributed through the soil, and its beneficial effects only accrue after it has gone into solution in the soil moisture. Having due regard to the cost of pulverising, it is usual to specify that a large percentage shall pass through a 60-mesh sieve.

Calcium oxide has a great affinity for water, and, as previously stated, the lump form is readily reduced to a powder when it is brought in contact with water. The same effect takes place when the lumps are exposed to atmospheric moisture. It is generally changed to the slaked or hydroxide form before being applied to the land. As slaked lime is a great deal more soluble, both in pure water and in water charged with carbonic acid gas, than is carbonate of lime, it follows that when it is applied to moist soil solution takes place and it becomes readily diffused throughout the soil.

Form in which to apply Lime.—In considering the advisability of using carbonate of lime or oxide of lime, it is important to bear in mind that it requires approximately

twice as much of the former as the latter to bring about the same chemical effect. Also, as slaked lime contains the water that has combined with the oxide, its actual value weight for weight is lower than that of quicklime. Two parts of oxide (quicklime) are equal to three parts of hydrate (slaked lime), or four parts of carbonate (limestone); 100 lb. of limestone are approximately equal to 75 lb. of slaked lime.

Tests conducted with carbonate of lime and oxide of lime at various experiment stations in the United States indicate that there is no practical superiority of one form of lime over the other, provided that 80 per cent of the limestone will pass through a sieve having 100 meshes to the inch, and that the two materials are used on the basis of the actual calcium present.

Method and Time of Application.—As regards the time and the method of application, it should be observed that carbonate of lime in any of the forms previously mentioned may be applied at any time, for it produces no injurious effect on seeds or young plants, and does not tend to set ammonia free from stable manure. It should not, however, be mixed with or be applied at the same time as acid phosphate, because there would be a risk of changing the water-soluble phosphoric acid to an insoluble form.

More care requires to be exercised in regard to the time of application of quicklime and slaked lime. They should not be allowed to come into contact with seeds or young plants, nor should they be mixed with or be applied at the same time as acid phosphate or stable manure.

It is desirable to have the lime as thoroughly and uniformly distributed through the soil as possible. Probably the most general and satisfactory practice is to apply it after ploughing, and then to harrow it in. There are various types of lime-spreaders on the market, but farmers often devise apparatus for this purpose that proves satisfactory.

Rate of Application.—Experiment and experience must decide whether it is preferable to make a large application once in several years or smaller applications more frequently. The rate of application must obviously depend on the soil's requirements; usually about one-half a ton or more per acre of quicklime, or the equivalent of carbonate of lime, suffices, but good results are frequently obtained with smaller quantities.

Applications in excess of that which can be held in the soil will result in leaching and loss, but this circumstance is most likely to occur on light soils lacking in organic matter.

Testing for Soil Acidity.—Although the farmer may by observation and experience decide that his soil requires lime, still the reasons for this demand are not always apparent. This is especially the case with regard to soil acidity, for many cultivated soils that are slightly acid offer no indications that afford conclusive evidence of this fact. It is true that certain types of indigenous vegetation often indicate acid soil conditions, and a soil with a high content of organic matter may be assumed to be acid, but generally it is necessary to test a cultivated soil for slight acidity. A laboratory test will often indicate whether it is advisable to use lime, but the results obtained in the laboratory are not always in accord with actual field experience, and for this reason it is important for a farmer to experiment with the soil in the field, in order to determine the response to liming.

In testing for soil acidity the litmus-paper test gives reliable results. Litmus is a dye that changes colour when it is brought in contact with acids or alkalies. Blue litmus paper when brought in contact with moisture and acid will turn red, and conversely an alkali will turn red litmus paper blue. A common method of conducting the litmus test is as follows: Moisten the soil to a compact mud and allow it to remain for a short time; insert the litmus paper in an opening made in this, close the soil around it for a short time, and examine it later for any colour change. The staining of the surface of the paper by adherent soil, or a bleaching of the blue colour by soil moisture, must not be mistaken for a change to red. On the other hand, numerous soils which do not exhibit a strongly acid reaction to litmus paper may require a considerable quantity of lime before they will show an alkaline reaction with red litmus paper, and will therefore be benefited by an application of lime.

In considering the question of liming the matter of drainage must not be overlooked, for liming cannot take the place of drainage. The application of lime to a soil which is deficient in organic matter cannot be expected to give good results; nor does lime furnish any of the matters supplied by fertilisers, such as nitrogen, phosphoric acid, or potash. From

the preceding statements it will be apparent that the practice of liming is closely related to that of green manuring, and while good results may attend green manuring in the absence of liming, generally better results accrue if lime is applied as well. Moreover, leguminous crops generally require a plentiful supply of lime in the soil.

Soil Erosion.—In all cotton-growing countries soil erosion is responsible for the conversion of enormous areas of fertile land into what is often described as a “worn-out” condition. It has been estimated that, each year, certain rivers carry off in solution more than 400 lb. of solid matter per acre of land drained, containing sufficient plant food to produce a crop. Obviously, land depauperated in this manner must rapidly lose its fertility, unless the loss is replaced by natural or artificial agencies. Unfortunately, the physical condition of the land at lower levels than that eroded likewise becomes impaired, for the heavier, sandy particles are deposited first, and the finer particles, or clay, last. As neither sand nor clay is so productive as a soil composed of a proper blending of these two substances, it follows that this sorting process impairs the fertility of the soil on which the deposit takes place.

Erosion is primarily due to the failure of the soil to absorb the water that falls upon it; it is therefore most prevalent on bare slopes that are subject to heavy rainfall. In countries where shifting cultivation prevails, erosion effects are not so rapid, for weeds, and the growth of trees and bushes that were not uprooted when clearing operations took place, tend to check the evil when the land is temporarily abandoned; nevertheless, in course of time even such land steadily deteriorates through soil wash.

Terracing, deep and contour ploughing, hill-side ditching, the cultivation of cover crops, and the incorporation of organic matter in the soil are all conducive to the prevention of erosion, as also is the planting of trees on slopes, that are too steep for cultivation, above the cultivated area.

Hill-side Ditches.—Hill-side ditches should be principally employed to intercept surface water from higher lands adjacent to that under cultivation, and to carry it at a low velocity to the nearest open drainage channels. But as a perceptible draining off of the finer soil particles, and a

constant enlargement of the ditches is necessarily associated with this method, it is not otherwise to be recommended for general adoption.

Terracing.—Well-designed and constructed terrace systems successfully combat the evil, even on land with slopes as great as 30 per cent ; but generally slopes greater than 20 per cent can be more profitably devoted to grass and trees than crops such as cotton. The natural drainage on hill slopes is frequently so rapid that a deficient supply of water for crops results, but terracing is conducive to the detention of water above the terraces.

What is known as the broad-base, level-ridge terrace system, more especially when it is supplemented with efficient drains suitably located, generally gives the most satisfactory results, although it is best adapted for slopes up to 15 per cent. By this system no land is lost to cultivation, for the nature of the terraces permits of cultivation on them. The success of the system is largely dependent upon its being laid out properly, and this can best be secured by a good levelling instrument and a competent and experienced leveller. Work should commence on the highest terrace, each terrace being completed before commencing operations on another, and should follow approximately the contours of the land. A terrace should be at least 10 feet broad at the base and not less than $1\frac{1}{4}$ feet high. The line and height of a terrace having been marked out, it is usual to throw furrows with a plough towards the centre line from each side for a strip of from 15 feet to 20 feet in width. An extra large wing attached to the mould-board will materially assist in elevating the soil, and still further assistance of this nature may be obtained by employing road-graders and drags.

Terraces are very susceptible to erosion until they have become properly settled ; for this reason it is inadvisable to cultivate them the first year, so a cover crop should be grown on them.

The ideal to aim at is for the soil to absorb all rainfall, leaving none to run off the surface. The water thus absorbed is then retained in the soil or subsoil until it is utilised by the crop, while any excess either remains in the deeper subsoil as ground water, or feeds the permanent streams through seepage. Contour ploughing and cultivating methods will

tend to increase the base width of the terrace from year to year. Crop rows should, as far as practicable, run parallel with the terraces. At each ploughing the soil should be thrown towards the centre of the terrace, both to increase its width and to maintain its height. The result of all these operations is to produce an appearance of a succession of permanent waves, all of which are capable of being cultivated.

Crop Rotation.—The advantages of growing cotton in a rotation, instead of cropping cotton continuously, is generally recognised, not only on account of the increased yields of cotton and the other crops in the rotation that are obtained by this practice, but because of the value of crop rotation in aiding the suppression of pests and diseases. As regards the choice of crops for growing in rotation with cotton, this must obviously depend to a large extent on the local soil and climatic conditions, the farmer's domestic and farm requirements, and also on the availability of a profitable market for the crops grown.

Considered from the standpoint of the yield of cotton, crops that increase the amount of organic matter in the soil, such as hay and pasture, are likely to give the best results. In this connection the importance of the various clovers needs special notice, for in the usual English rotation the clover crop is considered to collect sufficient nitrogen for the production, in succession, of good crops of wheat, roots, and barley. The various crop rotations in use in connection with cotton cultivation in different parts of the world have already been mentioned in previous chapters.

Fallowing.—The fallowing of land is one of the oldest customs in agricultural practice. It is generally considered to be most economical where the rainfall is low and the soil too strong to allow of free percolation, its principal advantage being the conservation of soil moisture by the soil retaining any rain that the land receives. In addition, the stock of available plant food in the soil is increased by bacterial agency; weeds are destroyed before they seed, so that the land is cleaned, and weeds that are harrowed in serve as green manure.

It is usual to plough and cross-plough 6 or 7 inches deep, and then to harrow to reduce the surface soil to a fine state

of division, so as to conserve the moisture already in the soil. Soil in this condition readily absorbs any rain that falls upon it, and none is lost through running off the surface. If the surface becomes hard and caked after rain, moisture is conserved by harrowing to form a dry soil mulch. The land becomes cleaned of insects, which are exposed to the sun and depredators by the ploughing and harrowing operations, while the absence of cotton robs them of their food.

Preparation of the Land for Cotton Planting. --The method of preparing the land for cotton planting must of necessity depend upon the physical character of the soil, its condition as regards weeds and other wild growths, and the nature of the previous crop grown. Good drainage is essential, for if the soil becomes water-logged the roots of the cotton plants become asphyxiated, and boll- and leaf-shedding results. Subsoiling is more likely to be attended with good results where a clayey subsoil and a light soil obtains, than where the subsoil is light and the surface soil is heavy. Too deep ploughing of new land is inadvisable, as this is conducive to bringing the new subsoil to the surface and burying the weathered soil too deeply. This practice may be more usefully adopted at a later date, when the surface soil tends to become "worn out".

In the United States land is usually ploughed for cotton to a depth of from $5\frac{1}{2}$ to 6 inches, but light sandy or loamy soils are ploughed deeper than the heavy clay soils. It is essential to put the land in a good state of tilth, and when the land is in good condition this may usually be done with one ploughing and one harrowing.

As regards the advisability of planting the seed on raised ridges, it is to be observed that on stiff, poorly drained soils ridging ameliorates aeration conditions, and on rich land it checks weed growth by lessening the water supply. Where heavy rains occur, ridges are an important factor in checking erosion. On the other hand, ridges hinder cultural operations and cause loss of soil moisture; it is therefore inadvisable to grow cotton on ridges if soil moisture is likely to be inadequate.

The planting of cotton seed on newly-ploughed land should be avoided; if possible, planting should be delayed until after the soil has been settled by rain. Very loose soils

are benefited by rolling to compact the seed-bed and to conserve soil moisture.

Cotton Seed for Planting.—The importance of planting good pure seed cannot be too strongly emphasised. The manner in which cotton rapidly deteriorates through mixing together the seed of different varieties should be constantly kept in view. When cotton plants of different varieties are cultivated in close proximity, cross fertilisation is effected by the aid of insects and other agencies, which transport the pollen from flower to flower, and deterioration naturally results from this promiscuous interbreeding.

Mixture of Seed in Ginneries.—The extent to which cotton seed is mixed in the ginneries is not sufficiently appreciated. This may be due to the circumstance that the seeds of many of the commonest varieties are so much alike that to distinguish between them is practically impossible. It has been proved that, when different kinds of cotton are ginned consecutively in the same gin, unless proper precautions are observed, there is a mixture of at least three varieties, and as much as from 15 to 26 per cent of the seed of the variety just previously ginned is mixed with that under treatment. It will readily be understood that, when this procedure prevails from year to year, a farmer who has commenced with planting a pure, improved variety of cotton soon finds that his crop deteriorates, and that it comprises a heterogeneous mixture of varieties.

Causes of Seed "running out".—The popular idea, which is prevalent among farmers in the United States, that cotton varieties "run out" in a few years, and that new seed must be introduced from other districts, is doubtlessly based on the deterioration that results from seed mixing in the ginnery and crossing in the field. If proper precautions are taken regarding ginning, selection, and isolation, the best-known varieties of cotton may be grown continuously for many years with no indication of "running out".

Storage of Seed.—If good germination is to be obtained, it is necessary to plant seed of good quality. Provided proper precautions be observed in storage, the germinating power of cotton seed need not be seriously impaired if it is stored for several years. If a cotton seed is cut transversely and examined by a lens, a number of tiny spots will be seen

that vary in colour from yellowish-brown to deep green ; this deepening of tint is an infallible test of the age of the seed, for the colour of these spots darkens with age.

The primary precautionary measure to observe in cotton-seed storage is to avoid heating, which adversely affects germination. Seed cotton, which is harvested early in the season, while it is green, or when it is moist, and is stored in close receptacles, is subject to heating. When it is ginned in this condition, and the seed is stored in large heaps, it rapidly heats, unless it is constantly stirred.

Bacterial and fungoid infection is a source of serious deterioration of lint, and it is to be sought for and controlled in the unginned rather than in the ginned cotton ; for cotton that has been exposed to damp storage prior to being ginned is much less resistant to bacterial or fungoid attack during subsequent normal storage than is cotton which has been stored under dry conditions previous to being ginned and from the time the crop was picked. Sun-drying the seed cotton is therefore to be recommended, while the practice of damping cotton both before and during baling is to be deprecated.

Seed which is in good condition may be stored in bulk or in sacks. Economy in handling is effected by sacking it direct from a recleaning and grading machine, for one man is able to sack the seed as fast as it issues from the machine, whereas two men are necessary to do this work if the seed is in bulk. It is preferable to use new sacks, and those made of 8 oz. burlap are satisfactory. It is convenient to have a uniform quantity of seed placed in each sack, and 100 lb. or 112 lb. may be the weight chosen according to whether the short or long ton is in use. Greater security is ensured if the sacks are closed by sewing instead of by tying.

The seed should be stored in well-ventilated buildings. The ideal type of building has the floor raised above the ground, with double walls, and abundant ventilation beneath the floor and between the roof and the top of the walls. Concrete floors are to be avoided, while in a brick or concrete building the seed must not be piled high against the walls.

Inferior Quality of Commercial Seed. — Approximately 30 per cent of the cotton seed used for planting purposes in the United States is procured from commercial sources, and

usually its quality is not of a high standard, for many of the seed merchants have exerted little effort to improve either the commercial or the agricultural value of the commodity. It is important that seed for planting purposes should be selected from plants that are true to type and of pure variety. It should be well matured, delinted, recleaned and graded, free from disease and insect pests and insect injury, with powers of germination not lower than 88 per cent.

Delinting Seed for Planting.—It is considered that the cotton seed requirements of the United States cotton-growing industry could be reduced by 100,000 tons, and that 60,000 bales of linters could be saved, by the more efficient removal of the surplus lint, extraneous matter, and small and light weight, inferior seed, by the application of methods that are now available.

The advantages of delinting cotton seed are that germination is rendered more uniform and accelerated, and with the aid of less moisture. Delinted seeds come into closer contact with the soil moisture, and germinate two or three days earlier than undelinted seeds, which have a variable quantity of lint left on them. In the process of germination, the seeds are pressed up through the soil on the cotyledons of the seedlings, so that delinted seeds offer much less resistance. There is a marked economy in the planting of delinted seed, for it is possible, both by machine and by hand, to distribute a smaller quantity, and more uniformly with equally effective results.

It is estimated that, in the United States, the cost of delinting cotton seed for planting purposes should not exceed \$5 per ton, but its agricultural value is infinitely greater than this sum represents.

Germination Tests.—It is advisable to test the percentage of germinable seed before planting takes place. Commercial germinators may be purchased for £2 or £3 each, but quite satisfactory viability tests may be made in moist sand, fine soil, blotting-paper, or flannel placed in ordinary table plates. The material chosen must be kept warm and moist. The results of such tests furnish a valuable guide to the farmer in regard to the rate that he must plant the seed in the field.

Naming of Varieties.—Seed dealers often give their seed trade names, which do not distinguish true varieties. Con-

fusion is also caused by the addition, without justification, of descriptive terms to the name of the variety, such as "early", "late", "improved", etc. Another objectionable practice is that of adopting descriptive phrases and abandoning the name of the variety altogether. The above-mentioned practices that prevail in the seed trade will serve to indicate the necessity for procuring cotton seed from a reputable source.

Should a planter contemplate testing a new variety, he should, whenever possible, obtain information as to its origin, results as to cultural tests, and its soil and climatic requirements. It is preferable to purchase cotton seed by weight rather than by measure. The promiscuous and uncontrolled introduction of cotton seed by private individuals is likely to be most injurious, both on account of the danger from pests and diseases, and also from crossing, and its introduction should therefore be controlled by a competent authority. In new cotton-growing countries in the British Empire the importation of cotton seed is prohibited, except with the special permission of the Agricultural Departments.

Sowing Cotton Seed.—The distances at which various kinds of cotton are planted in the different cotton-growing countries of the world have already been described. In the fertile soil and forcing climate of West Africa, when the farmer grows his cotton plants in clumps he, no doubt unconsciously, suppresses the vegetative organs of his strong-growing native plants. This suppression is likewise practised in India and other countries, where crops are grown, along with cotton, that mature early and are harvested while the cotton is still young. Vegetative growth is of course checked by the arrival of dry weather, but too rank growth is frequently more injurious from an economic standpoint than stunted growth, and especially where close planting is practised.

It is in many cases imperative to determine the optimum planting period, for it is frequently of the highest importance to correlate, as far as possible, the appearance of disease with meteorological conditions, to avoid exposing the crop to undue fluctuations and consequent lowering of the plant's vitality.

If the slope of the land permit, the seed should be sown in rows running east and west, so as to expose the plants to

the maximum of sun and warmth, for if the rows run, say from north to south, they shade one another.

Many excellent cotton seed planting machines are on the market by which the rate of sowing may be regulated from a few lb. to as much as 100 lb. per acre. These machines distribute the seed evenly, and are propelled by a horse or a mule. Those fitted with a special attachment, known as a "lister", are to be recommended, which can be regulated so as to ensure the dry surface soil being pushed away and the seed being deposited evenly in the moist soil. The rate of sowing must of necessity be governed by the planting-distance chosen and the quality of the seed ; but the planting of a large number of seeds is advantageous, for it aids the young seedlings to push their way through the soil crust that forms after rain. The seed should not be covered with more than $1\frac{1}{2}$ to 2 inches of soil, or there is a danger of the young plants failing to push their way through the soil to the surface.

Upland cotton seed is planted in the United States at the rate of from 2 to 4 pecks per acre, a larger quantity being planted on clayey soils that bake readily than on light sandy soils.

Treatment of Fuzzy Seed.—With a view to facilitate the planting of fuzzy cotton seed in India, the seed is piled in a heap and a watery mixture of cow-dung is poured over it. The seed is then rubbed by hand so as to give each seed a coating of cow-dung, and it is then dried in the sun. This procedure causes the short fuzz to adhere to the seed, separates the seeds, and renders them more readily handled for planting purposes. The same purpose is served in other countries by treating the seed with a starch gruel made by boiling maize or some other cereal meal.

Method of planting Rare Seed.—If rare seed, which it is desirable to propagate as rapidly as possible, is planted in the ordinary way, there is obviously much waste of seed, even when planting is done by hand. In order to obtain a regular stand of plants, it is customary to raise more plants than it is desired to retain ; moreover, perfect germination is unlikely to take place and all the seedlings do not survive. A single seedling may not be able to force its way through the soil crust, whereas the combined effort of several seedlings is

more successful. A drastic thinning out, and destruction, of surplus plants, generally amounting to from 50 to 75 per cent of the field, is thus rendered necessary.

Certain varieties of cotton are readily distinguishable from one another, even in the seedling stage. This is the case with Upland and Egyptian, and Upland and Sea Island seedlings. The seedlings of Egyptian and Sea Island, on the other hand, are very difficult of distinction. Rare seed may be conserved by mixing and planting it along with that of a variety which can be readily distinguished from it in the seedling stage, and be removed, thus avoiding undue waste of the rare seed, and at the same time obtaining the advantage of close planting. Beans and peas may be planted along with cotton seed with a similar object in view. By the adoption of either of these methods quite 50 per cent more land can be planted with the rare seed.

Thinning the Plants.—When the cotton plants are about 6 inches high, it is necessary to thin them out to the distance apart that is considered suitable for the type of cotton under treatment, having due regard to the local soil and climatic conditions. At this period the plants have usually passed the stage at which they are most susceptible to the diseases and pests that attack seedlings.

Hand thinning is detrimental, as the ground is loosened by pulling up the plants, and soil moisture is lost. The surplus plants should be chopped off just below the ground surface by means of a 7-inch-wide hoe having a sharp cutting-edge. The hoe may be kept sharpened by using a 10-inch flat file. Advantage should be taken of the thinning operation to hoe up any weeds that may have appeared, and in doing so to draw the soil towards the seedlings, as a protection from wind. About a fortnight later the plants should be gone over again to remove, with the hoe, any plants that were overlooked at the first thinning operation and to remove weeds.

Cultivation after Planting.—The cotton plant has a deep tap-root system with comparatively few surface roots; so that advantages accrue from cultivation by liberating plant food in the soil, the conservation of soil moisture, and soil aeration, without undue injury to the root system. The average number of cultivations given to cotton after planting

in the United States is five or six, and within reasonable limits there appears to be a direct correlation between the number of cultivations given and the yield of cotton.

The suppression of weeds by cultivation is likewise an important factor, for they compete with the crop for food, space, and light. Perennial weeds often continue to function, even when suppressed by cultivation ; hence the desirability for deep ploughing before planting when they are abundant, although cultivation is advantageous in removing the aerial competition.

The depth of cultivation must be governed to a large extent by the character of the soil, but with proper regard to the danger of inducing rank growth on the one hand or stunted growth on the other. Generally a deep, rich soil requires a lighter cultivation than a poor, shallow soil.

Cultivation must cease when the bolls are fully grown ; besides, at this period it is usually found that the plants have developed to such an extent that they cover the ground, and it is not feasible to conduct cultural operations without injuring them.

Single-Stalk Cotton Culture.—Single-stalk cotton culture, or what was described as a new system of cotton culture, was brought forward by the United States Department of Agriculture in 1913. It has for its basis the fact that the characteristic vegetative and fruiting branches of the cotton plant may be controlled by cultural methods. In this connection the primary objective in view is the suppression of the vegetative branches that are borne on the lower portion of the central stem—they are usually confined to the six lowest joints—and which often equal, and sometimes even exceed, in size that of the central stem of the plant. When cotton is grown as a short season annual these vegetative branches often do not produce flowers and fruits ; their suppression consequently limits the undue crowding of the plants and unfavourable competition between the two kinds of branches. The benefits derived are earlier crops, larger yields, and protection from insect attacks that occur late in the season.

The ideal aimed at is the production of a plant with a single, erect, central stem, carrying numerous well-formed fruiting branches, but no vegetative branches. This type of

plant provides more space between the rows, and encourages the development of the lower and early fruiting branches.

The vegetative suppression is brought about by deferring thinning operations until the plants are from 6 inches to 12 inches high. Plants which are allowed to remain closer than 6 inches apart in these early stages show little tendency to produce vegetative branches. Undue crowding of the plants is of course injurious, so that if the seedlings are less than 2 inches apart in the rows a preliminary thinning is necessary. Likewise, unduly protracted thinning operations may prove injurious. It will thus be seen that, if the desired results are to be attained, a proper appreciation is essential of the underlying principles that govern the production of the vegetative branches.

It would obviously be inadvisable for a farmer to apply this system of cultivation to his whole crop, until he had experimented to ascertain the best distance to leave the plants apart, having proper regard for local soil and climatic conditions, and the habits of growth of the varieties under cultivation. The narrow erect habit, which late thinning induces, admits of much closer spacing of the plants in the rows than is usually practised, and may range as low as from 6 to 10 inches apart for Upland cotton. Individual plants may produce fewer bolls, but rows of single-stalk plants yield a greater total number of bolls, and consequently give a better crop, than rows of plants grown by the usual cultural systems in vogue.

In 1915 the United States Department of Agriculture conducted twenty-one experiments with single-stalk cotton culture in different parts of the States of Louisiana, Arkansas, and North Carolina. They were located in ordinary fields of cotton; the single-stalk culture being compared with older methods in alternate blocks or rows. The plants in the single-stalk rows were spaced 6 to 10 inches apart, 8 inches being the standard aimed at. In the old-method rows the plants were spaced, according to the usual practice, at from 18 to 36 inches apart. The plants grown under both methods received identical treatment, except that the single-stalk rows were thinned later and the plants were left closer together as the method requires.

It was found that there was no significant difference in

the quality of the lint produced by the two methods of culture, for the lint percentage, the size of the seed, the lint index (weight of lint on 100 seeds), and the grade and length of the lint remained about the same. Single-stalk culture gave greater total yields in eighteen of the twenty-one experiments; it gave greater yields at the first picking in sixteen of the twenty-one experiments; it gave greater yields at the second picking in nine to eleven cases; and it gave greater yields in the only cases where third pickings were made. Some of these differences were so small as to have little significance in themselves, but there was a general increase throughout the entire series of experiments, in several cases by more than 20 per cent. In five of the experiments the yields of seed cotton were in favour of the single-stalk system by as much as 20 to 39 per cent.

Cotton Culture under Irrigation.—There is every indication that in course of time the world's cotton supplies will become less dependent on climatic vagaries, and that more cotton will be produced under irrigation. New areas, hitherto unsuspected of possessing cotton-producing capabilities, will be developed by irrigation, and especially in such countries as West Africa, Brazil, India, Russia, and Australia. In recent years the possibilities in this connection have been forcibly demonstrated in Sudan, India, the South-Western States of America, and Iraq.

Choice of Land.—In the choice of land for cotton cultivation under irrigation the character and depth of the soil should be carefully examined, as well as the presence of injurious salts that are usually grouped under the common name of alkali, and the facilities for drainage. The native vegetation affords one of the best indications of the character of the soil. In the United States the presence of cactus, sagebrush, and buffalo grass indicate fertile, easily tilled, well-drained soil, while the presence of saltwort, salt weeds, and creosote bush indicate a heavy soil more or less impregnated with injurious salts.

Deep soil is of importance, because the cotton plant draws its supply of food and moisture from considerable depths, while the top layer of soil serves as a blanket to protect the moist soil below. The storage of moisture and deep rooting is checked if an impervious stratum occur within, say, the

first 4 or 5 feet. A porous gravelly stratum often causes loss of irrigation water through too rapid percolation beyond the root zone. Generally, sandy soils irrigate well, but clays do not absorb water readily; they are difficult to cultivate when wet, and bake and crack when dry. The former will absorb sufficient water in twenty-four hours after irrigation to become moist to a depth of 2 or 3 feet, while the latter are sometimes so impervious that it is difficult to moisten the soil more than a few inches below the surface.

A smooth surface and a uniform slope of from 1 to 2 feet in 500 feet afford ideal conditions for preparing the land at a low cost for irrigation, while the slope is conducive to good drainage. Good drainage is essential, for a certain amount of seepage into the subsoil must take place if water sufficient for crop requirements is to be available, and unless this can drain away, the level of the ground water will be raised and cause an accumulation of alkali, with consequent damage to the crop's root system.

Canals and Ditches.—No matter what the source of the water supply may be, a network of ditches is required to convey the water to different portions of the farm. Contractors, under competent engineers, generally build the canals and large ditches, but the farm supply-ditches are usually demarcated and built by the farmer. These ditches should, when possible, be made alongside field or fence boundaries, in order not to impede transport; but should the grade be steep it will be advisable to lay them out in curves through the fields.

Surface Levelling.—The proper preparation of the land surface, so that it may be inexpensively, readily, and uniformly irrigated, is of prime importance, and this is not practicable if the surface is left rough and uneven so that water cannot be uniformly applied. When land is properly levelled less water is needed and the irrigation water can be more readily controlled. Unless the land is levelled, drought may prevent the germination of the seeds or stunt the growth of the plants in certain areas, while in others injury may be done through over-watering encouraging too luxuriant growth and the late development of the bolls; or certain areas may dry out during the growing season and necessitate

separate irrigation, which entails much extra expense for labour and water.

Levelling is greatly facilitated by a detailed contour survey. The larger vegetation must be removed, but the small forms of brush may be deeply ploughed in. Then follows harrowing, grading, and smoothing. There are several forms and sizes of satisfactory graders and scrapers on the market, the use of which materially expedites the rather laborious operation of grading.

Water Application.—There are many methods of applying the water, but cotton and similar crops that are grown in rows and cultivated are irrigated by means of furrows. Grading having been completed, the land should be divided so that each portion may be readily watered from a head ditch. The latter is fed from the main supply-ditch of the farm. The distance between the head ditches is largely governed by the character of the soil. In porous sandy soils the furrows must not be more than 100 yards long, but in less porous soils they may be from 130 yards to 330 yards long.

In this system of irrigation the principal difficulty is to divide the water more or less equally among a large number of furrows. If the farmer wishes to turn the water from the head ditch into, say, forty or fifty furrows at the same time, the flow will not be uniform unless some device is employed to lead the water from the ditch into the furrow. For this purpose a satisfactory square pipe may be made of wooden laths or half-inch boards, which is inserted into the lower bank of the head ditch opposite each furrow and 2 or 3 inches below the water level.

The head and length of the run should be so adjusted that the plot under treatment can be covered with water by the time that the irrigation has wetted the root zone of the crop. High heads are necessary for irrigating loose soils, and in flood irrigation to force the water over the land rapidly, whereas a longer length of run permits of more time for soaking on soils of heavier texture. Longer runs should be adopted on sloping land, but shorter runs, with a higher head, on flat lands, so as to cover the land without waste. On small areas, and with a small head, the furrow system of irrigation is more economical than flooding systems.

Small ditches, that convey the water to the point of application, are more economical than broad shallow ones, for the latter expose the water to loss by evaporation and percolation.

Water Conservation.—The amount of water that crops actually use comprises only a small part of that which is applied for irrigation purposes. Large quantities of water are lost in the earthen canals and ditches by absorption and seepage. Where water is scarce it therefore behoves the farmer to check this wastage by lining these channels with cement, concrete, plaster or clay puddle, and to substitute flumes or pipes for earthen ditches.

A rough uneven surface is also the cause of needless water wastage, and entails more work in spreading it over the surface. Another source of wastage is due to lack of attention to the water flow. The water is often turned on and left running much longer than is necessary; the land receives too much water and the adjoining roads and fields are injured by the overflow. On the other hand, water may be wasted by too shallow and too frequent irrigation. Three-fourths of the water applied may be wasted through just wetting the surface and neglecting to cultivate it afterwards.

“Free Water” in the Soil.—It is important to prepare the soil so that the water will readily percolate, and sufficient water should be applied to moisten the subsoil. The amount of water to apply at one time and the frequency of irrigations are governed by the nature of the soil and climate and the condition of the crop. It is important to bear in mind that the principal object of irrigation is to supply the amount of moisture required by the crop, and that too much moisture is just as injurious as too little. The irrigator is mainly concerned with what is known as the “free water” in the soil. Expressed in general terms, a soil should contain about 1 lb. of free water to every 10 lb. of soil as it is taken from the field. The amount of free water present in the soil may be roughly ascertained by taking samples with an auger from the area occupied by the roots of the crop. These should be weighed and then spread out thinly on a metal sheet and left exposed to the sun for a day, and then re-weighed. The weight lost in the drying represents the weight of free water in the soil, so that if the weight lost is less than 10 per cent

further irrigation is indicated, whereas if the weight lost is more than 10 per cent over-irrigation is indicated.

Quantity of Water to Apply.—As regards the quantity of water to apply in one irrigation, it is to be observed that the application of 4 inches of water in depth over the whole surface is sufficient to moisten the soil to a depth of 4 feet. In practice, however, a larger volume is required to effect this, for the top layer always receives too much water, and a portion passes off into the air in the form of vapour; there is also loss through seepage. For light irrigations, when it is desired to moisten the soil to a depth of $1\frac{1}{2}$ foot, from 4 to 6 inches of water are necessary, whereas for heavy irrigations, when the crop is deep rooted, as much as 9 inches may be necessary.

Few loamy soils will take up and hold as much as 2 inches of water per foot of soil. Fine sandy loams take up $1\frac{1}{4}$ to $1\frac{3}{4}$ inch per foot of soil, fine sand about 1 inch per foot, while coarse sand has a usable water capacity of about $\frac{1}{2}$ inch per foot. The quantity requisite for irrigation, therefore, in each case should not exceed the depth given multiplied by the depth of soil occupied by plant roots.

Drainage.—Wherever irrigation is practised, *experience shows that the most serious danger is lack of drainage.* Irrigation raises the ground water, and with it are brought the salts dissolved from the soil; this salt-laden water is brought to the surface by capillarity, where it evaporates, leaving the salts behind to the injury of vegetation. The only effective remedy is proper drainage, but the economical use of water and good cultivation are palliatives.

Cultivation of Irrigated Land.—In fertile soils, with a good supply of available plant food, the plant does not need so much water to procure the nourishment that goes to form a lb. of dry matter as in poor soils, and it is well recognised that fertiliser application reduces the plant's water requirements on light soils.

Cultivation should follow as soon as possible after irrigation with the view to check evaporation, thereby conserving the moisture in the soil and extending the periods between successive irrigations.

If the frostless season is comparatively short, as in the Salt River Valley, United States, where the normal growing

season is only just long enough for the full development of the Pima-Egyptian variety that is generally grown, extreme care is essential in choosing a date for planting and to keep the plants in full activity during the whole period. Plants that are sparingly supplied with water throughout the season bear a greater number of bolls late in the season than those that are more generously supplied with water.

Immediately previous to planting cotton the land should be thoroughly irrigated, so as to wet the soil to a depth of 4 or 5 feet, and to provide a moist seed-bed and to store as much water as possible in the land for the cotton crop. This should be followed by a disc or spring-tooth harrow, and then by a drag or smoothing harrow, so as to prepare a well-pulverised seed-bed.

Until the plants are too large to permit of cultivation the soil should be cultivated after each irrigation, both to keep down weeds and to provide a good soil mulch. A disc cultivator may be used for the early cultivations, but the use of cultivators fitted with shovels and sweeps is preferable later, as they destroy more weeds and improve the condition of the soil for irrigation.

New land does not hold water as well as old land, and it generally requires more frequent irrigation. Too much irrigation early in the season tends to stimulate the vegetative growth of the plants at the expense of fruit production, and likewise increases the difficulty of picking, because it causes the plants to grow to a larger size. But during the flowering and bolling periods ample irrigation is likely to check boll shedding.

Provided that the soil is well saturated before planting is done, it should not be necessary to irrigate again for several weeks. The general condition of the plants is the safest guide for irrigation; for it is not necessary to irrigate so long as they continue to grow vigorously. A slight drooping of the foliage is not necessarily an indication of a lack of moisture at the root, for a sudden change from cool to hot weather will often produce this effect. Generally, irrigation should only be applied when the moisture content of the soil falls near the wilting point of the plants, *i.e.* the point at which growth stops.

Picking Cotton.—Picking is the most costly operation

associated with cotton production, and it is probably on this account that it is all too frequently carelessly done. The value of a good crop of cotton is often sadly depreciated through the admixture of leaf, trash, and other foreign matters during picking operations. Mechanical cotton pickers have been introduced and even favourably reported upon from time to time ; but the ideal picker is still unavailable, although it is certainly the most desired labour-saving device connected with cotton growing.

In the early days of the American cotton industry the collection of 50 lb. of seed cotton was considered a fair day's work, but in 1840 from 150 lb. to 200 lb. was demanded per picker, and this is the amount collected by good pickers to-day. Usually a beginner collects 75 lb. of seed cotton per day of eight hours, and as experience is acquired the amount picked increases to 100 lb. The method of picking adopted in the United States has already been described in Chapter III.

If cotton is picked before it is properly mature the fibre is weak and it does not acquire the twist which is so essential for good-quality spinning, and besides it is more difficult to dry. What spinners describe as "nep" in cotton is caused by the presence of weak fibres. Damp cotton is difficult to gin, and is liable to heat when stored. On the other hand, if picking is unduly delayed the fibre loses lustre, strength, and silkiness. Over-sunned cotton has a harsh appearance, with a loss of bloom and character.

If leaves, trash, and other extraneous matters become mixed with the seed cotton they are difficult to remove, and they depreciate the value of the ginned lint. This applies more particularly to long staple cotton, because it is ginned in roller gins, which are not so well adapted for cleaning cotton as saw gins.

Damage is not necessarily caused by light frosts that occur late in the growing season ; they may even prove advantageous by causing some of the leaves to fall, which permits the sunshine to penetrate to the bottom of the plants and encourage the late bolls to open.

CHAPTER XII

HANDLING AND MARKETING THE COTTON CROP

Early ginning methods—Whitney's saw gin—Macarthy's roller gin—Saw gins—Pressing and baling—Weighing machines—Hullers—Seed cotton openers—Roller *v.* saw gins—Large *v.* small ginneries—Marketing cotton—Liverpool cotton "Futures" contract.

Early Ginning Methods.—The operation of separating the lint from the seed of seed cotton is known as ginning. "Gin" is an abbreviation of the word engine, which came into use soon after the application of steam to motive purposes. The foot roller and the "churka" gins have been in operation in India from time immemorial. A detailed description of them was written by the explorers who accompanied Alexander the Great to India. The foot roller is now practically obsolete; originally it consisted of a flat stone, on which the seed cotton was placed, and a wooden roller moved by the foot was used to press the seed out. The "churka" is still in use, but it has been improved by modern devices and is sometimes driven by water or steam. As used in early days, it was constructed of two rollers of wood or iron, which were geared to revolve towards each other. The seed cotton was introduced between the two rollers; the lint passed through leaving the seed to fall down in front. Two persons were required to operate it—one to turn the rollers and the other to feed the seed cotton between the rollers; a day's output was only 4 or 5 lb. of lint. The "churka" was early introduced into the United States from the West Indies, but its operation was soon proved to be too tedious for the commercial production of short staple cotton, although it probably injures the lint and seed less than any modern apparatus. The West African native's "gin" consists of a block of hard

wood and a native-made, smooth iron roller, about a foot long, $\frac{3}{4}$ inch diameter in the centre, tapering down to about $\frac{1}{4}$ inch diameter at the ends. The seed cotton is placed in small quantities on the wooden block and the seeds are rolled out by the roller.

Whitney's Saw Gin.—The invention in 1793 of Whitney's saw gin, for ginning the fuzzy-seeded Upland cotton, supplied an enormous impetus to the cultivation of this type of cotton, for it removed the principal obstacle in the way of its profitable production. As originally introduced, it was composed of a cylinder fitted with wire teeth, which drew the lint through a wire screen, leaving the seed behind, and the output was about 50 lb. of lint per day. Later improvements substituted circular steel saws for the wire teeth, and these, without altering the essential principle, increased the capacity of the machine, with the aid of horse or water power, to about 330 lb. of lint per day. The evolution of the saw gin synchronised with the inventions of textile machinery in England by Arkwright, Hargreaves, and Cartwright, which revolutionised the textile industry by the manufacture of cheaper cotton goods, and simultaneously increased the demand for raw cotton.

Macarthy's Roller Gin.—The saw gin was found to injure the lint by cutting it; besides, its use was unnecessary for Sea Island and Egyptian cottons, which have smooth seed and long fibres that are readily detached from the seed. This resulted in the invention, nearly fifty years after the invention of the saw gin, of Macarthy's roller gin for treating such grades of cotton.

Several types of roller gins have been invented since that date, but the Macarthy is the best example of the roller gin in use to-day. Two kinds are manufactured, known respectively as single action and double action.

The single-action Macarthy roller gin is mounted on an iron frame, and, briefly described, consists of a leather roller with a roughened surface in which spiral grooves are cut, and a fixed doctor knife against which the roller works; underneath the doctor knife, and set close to the leather roller, is a reciprocating beater knife operated from a crankshaft; across the machine a seed grid is fixed which allows the cleaned cotton seed to pass through to the back of the gin;

over this grid a push board, moved by eccentrics, slides and pushes the seed cotton against the doctor knife.

The leather roller draws the lint between it and the doctor knife and the reciprocating beater knife cleans off the seed. As the lint passes through on the leather roller to the other side of the machine it is cleaned off by means of a stripping board or leather flap roller.

Recently a vibrating seed grid has been invented, which prevents the seed cotton from forming into a roll or rope upon the seed grid and thus decreasing the lint output.

The double-action roller gin is similar to the one just described, except that it is fitted with two beater knives, by means of which a double stroke is obtained which causes less vibration.

Various kinds of apparatus for automatically feeding seed cotton to roller gins have been invented, but none has proved altogether satisfactory, for it is found difficult to regulate the supply of seed cotton to the gin and prevent its becoming choked; the best results have therefore been obtained by feeding the seed cotton to the gin by hand. The amount of seed cotton which can be fed into the roller gin at one time is comparatively small, and careful hand-feeding is necessary for the best manipulation of this gin and the greatest output. For an automatic feeder to be successful it will have to be provided with means for automatically regulating the supply of cotton, or some method will have to be devised for stopping the machine when it becomes choked with seed cotton.

For the best results to be obtained it is essential that these machines be properly set, and great experience is required to adapt them to varying lengths of lint staple. Careless setting results in decreased output. Production is likewise governed by the type of cotton under treatment. With a speed of 150 revolutions for the leather roller and from 700 to 1000 revolutions for the crankshaft, per minute in each case, the single-action gin has an output of from 30 lb. to 90 lb. of lint per hour. With a speed of 150 revolutions for the leather roller and a crankshaft speed of 600 revolutions, per minute, the double-action gin has an output of from 40 lb. to 70 lb. of lint per hour.

The power required to drive these gins is 1 I.H.P. and

$1\frac{1}{4}$ I.H.P. for the single-action and double-action gin respectively.

The different methods of ginning and baling cotton in vogue in the chief cotton-producing centres have already been described in preceding pages.

Saw Gins.—In the United States the old-fashioned ginning outfits propelled by horse, mule, or water power are being gradually supplanted by modern steam or electric installations, equipped with various labour-saving devices.

Briefly described, a modern power-driven saw gin consists of a variable number, 20 to 70, but usually 60 or 70, of thin steel disc saws, generally 10 inches in diameter, fixed on a cylinder. This cylinder revolves in a box in which is a grating of steel bars, through which the saws project and rotate. As the seed cotton is fed to them the teeth grip the fibre and draw it from the seed; the seed being left behind, as the openings in the grating are too narrow to allow it to pass through.

Usually the seed cotton is brought loose in waggons to the ginnery, and is sucked through a pneumatic tube and taken direct to the gin stands. *En route* to the gins it passes through a cleaner, where it is “agitated” on a screen to remove foreign substances; it is then dropped into the gin feeders, where it is further cleaned. It is next delivered to the gin at such a rate that the box is not gorged, but assures a moderately soft but pliable ginning roll. The movement of the saws through the seed cotton, held by the grate in the roll box, imparts to it a rotary motion in the direction opposite to that in which the saws move, and this is known as the roll. When the saws revolve slowly, a loose roll is formed, but a high speed gives a tighter and more compact roll. The saws usually revolve at the rate of 400 revolutions per minute.

Just below the cylinder carrying the saws is a rapidly revolving brush, which takes the lint from the teeth of the saws as it enters the box. American saw gins are sometimes fitted with a fan in place of the brush to remove the lint from the saws. The seed falls into a trough and passes by suction to the seed store. Hulls, trash, and other foreign matters are either conveyed to the boiler-room for fuel or outside the ginnery to be used later for fertiliser.

The lint is drawn by suction into a closed flue that is situated behind the gin. A small pipe is inserted at one end of the lint flue, so that, in the event of a "flash fire" in the flue, a jet of steam may be turned on the lint, which at this period is in an extremely inflammable condition. Through the lint flue the lint is taken into the condenser and formed into a loose lap, from which it falls in folds into the press box for pressing and wrapping. Except in the areas where Pima-Egyptian and Mead cotton are grown, the whole of the United States cotton crop is saw ginned. Lint production varies from 4 to 6 lb. of lint per saw per hour. The power required is 1 I.H.P. for every 10 saws.

In the case of the fuzzy-seeded cottons a quantity of short lint adheres to the seed even after it has passed through the saw gin; this is removed by repassing the seed through a delinting machine. The latter closely resembles the saw gin, except that the saws are set much closer together and the grate fall bars are narrower.

Pressing and Baling.—Cotton is baled by various kinds of presses worked by steam, hydraulic, screw, or hand power. In the United States the screw press is largely used for baling purposes. It is provided with two boxes, which revolve round a central pillar on a circular platform in the form of a turn-table. The boxes are lined with canvas before the cotton is put in. The condenser of a ginning plant delivers the lint by means of a shoot into one of these boxes, and it is pressed down by a mechanical "tramper" or packer, which is operated by a steam cylinder arranged vertically above the press box. When lint sufficient to form a bale has been tramped the boxes are revolved, the empty one coming under the "tramper" and the packed one being placed over the screw press. The latter consists of a large and powerful screw, which is fixed in a pit under the box and is driven by powerful gearing. When it is set in motion the tramped cotton is pressed against the top of the press. When the bale has been pressed small enough, six metal bands are placed round it, the sacking is sewn up with string round the edges, the screw is lowered, the box is opened, and the completed bale is pushed out.

The normal density of the bales turned out by the ordinary screw press is 14 lb. per cubic foot. With this type of

press it is possible to make a bale of cotton in less than ten minutes.

In the United States the screw-pressed bales are covered with two pieces of jute sacking, but these are not long enough to meet over the ends or flat sides of a bale. These bales suffer drastic treatment by samplers, who slash a new hole in the canvas for each sample drawn. As each sample weighs about 1 lb., and every prospective buyer considers he is entitled to a sample, it will be appreciated how the bales become slashed to pieces. Objection to taking samples from the uncovered sides or ends of the bale is explained by the circumstance that it is more difficult to draw a sample from the hard-pressed sides of the bale, whereas a sample taken from the top or bottom of the bale opens up like the leaves of a book, owing to the manner in which the lint falls in folds into the press box. Also objection is raised to taking a sample from the press box on the ground that a sample of unpressed cotton does not look the same after it has been pressed.

With a view to economise freight space, the lightly pressed bales are reduced in size in a compress, which is a more powerful machine and is generally worked by hydraulic power. Compresses are established at the large railway centres and at the shipping ports. At the compresses the bales are unbanded, the top and bottom cloths being temporarily held in place by wire clips, rough pieces of sacking being used to cover up the sampling holes. After being re-pressed, whereby the density of the bale is increased to 30 lb. or more per cubic foot, eight metal bands are placed around each bale.

When a hydraulic press is used, the cotton can be pressed to a greater density than in the screw press, and compressing is not necessary. When this method of baling is employed, a powerful hydraulic press is let into the floor, the cylinder and ram being underneath in a pit; the top of the press is above the floor and is carried on four steel pillars. Two bale boxes move on rails which run through the centre of the press. The bale boxes have false bottoms, and a press block on the ram fits the boxes.

After a box has been lined with canvas it is filled with cotton from the gin condenser, and is then run under the

hydraulic press. The hydraulic valves are then opened and the ram raised, and the cotton is pressed to the required density. The bale box is next opened, and the box is run out of the press, but the pressed bale of cotton remains between the top of the press and the press block on the ram. In the press top and in the false box-bottom there are slots for the metal bands used for "tying" the bale. When these have been put in place, the canvas stitched, and the ram lowered, the completed bale is ready for removal. One box is filled with cotton while the other is in the press.

Short staple cotton, like that of India, can stand a pressure of 56 lb. per cubic foot. The Manchester Cotton Control Board has decided that American bales must not be pressed to a higher density than 36 lb. per cubic foot. The Egyptian cotton bale has a density of 38 lb. per cubic foot.

Weighing Machines.—An up-to-date ginnery is usually supplied with at least two weighing machines. One is in the form of a weighbridge with a capacity up to 10 tons and a platform measuring 14×8 feet. This is conveniently placed near the point where the seed cotton is brought to the ginnery and adjacent to the pneumatic suction pipe which delivers the seed cotton to the gin stands. All cotton can then be weighed before it enters the ginnery and an accurate account be kept of all cotton arrivals. It will be seen that the size of the weighbridge platform is sufficiently large to weigh the cotton in the carts or other vehicles in which it is transported to the ginnery.

The other weighing machine is generally let into the floor near the bale press, and has a capacity up to a ton. When a bale is taken from the press it is weighed and the weight stencilled on it. As the bale press is usually situated at the opposite end of the ginnery to that at which the seed cotton arrives, the arrangement of the weighing machines as described above avoids any interference with the handling of the arriving seed cotton and the despatch of the bales.

Hullers.—For the treatment of dirty seed cotton, and that which contains whole cotton bolls, stalks, and husks, a special type of gin known as a huller is used. The huller is fitted with a spiked drum or roller which revolves rapidly in the direction of the saws, and thoroughly loosens and cleans the cotton before it is ginned. The hulls, stalks, etc.,

are stopped by projections fixed close together on the grate bars and fall under the gin with the seed.

Seed Cotton Openers.—Certain short staple American, East Indian, and Levant cottons are of a woolly nature with the fibres interlaced into a more or less matted condition. With a view to disentangle the fibres preparatory to ginning, and thus to facilitate the ginning process, they are passed through a machine known as a seed cotton opener. A double-cylinder seed cotton opener is capable of opening a ton of seed cotton per hour.

Roller v. Saw Gins.—The microscopical examination of ginned cotton demonstrates that lint which is not readily separable from the seed, such as the *G. hirsutum* kinds, and which requires to be saw ginned, is ruptured and the ends are burst open owing to being torn from the seed cuticle. On the other hand, the readily separable lint, *i.e.* that which may be roller ginned, under the microscope reveals no such rupture after ginning, but appears to have separated from the seed naturally. In this connection it is to be observed that all the types mentioned in Section IV. of Chapter II., Botanical, are suitable for roller ginning, as the lint is readily separable from the seed in each case. It is significant that *G. Kirkii*, which is probably the only one absolutely naked-seeded cotton, is not cultivated at all, and the possibility of developing it by cultivation and selection appears to be well worth consideration.

With naked-seeded long staple cotton it is imperative to use roller gins, as saw gins ruin both the staple and the appearance of the lint by tearing it from the seed and dragging it through the grate bars in the roll box, while the brush action likewise roughly removes the lint. Moreover, long, silky-stapled cotton often gets stuck between the grate bars and jams the saws. The roller gently detaches the lint from its seed and retains the length of the staple to its fullest extent, while the roller action assists very materially in giving the lint the silky appearance which is characteristic of all better class cottons. In the Macarthy roller gin there is a certain “give” between the beater knife and the roller which eases the lint in its course between the doctor knife and the leather roller.

Roller ginning is more costly than saw ginning, for the lint

output from roller gins is much less, though this varies with different types of cotton. For the black-seeded cotton, such as that grown in north-east Brazil, a 50-saw gin, with 12-inch saws, would have an out-turn of about 450 lb. of lint per hour, as compared with an out-turn of 130 lb. of lint per hour from a single-action roller gin, if both are automatically fed, and the lint is automatically conveyed to the baling room in each case; *i.e.* the production rate ratio is 3.5 : 1. The ratio, however, increases in the case of fuzzy-seeded cottons to as much as 5 : 1, owing to the more positive action of the saws in detaching the lint from the seed. So that when the seed is fuzzy, and the lint is only of moderate length, too many roller gins would be required and saw gins would prove more economical. The choice of gin must therefore obviously depend on the advisability of sacrificing output for quality. Generally it may be stated that saw gins may be depended on to deal satisfactorily with lint up to a staple of $1\frac{3}{16}$ inch.

Large v. Small Gineries.—It is generally found that large gineries are much more economical than small ones. In the former case the lint can be at once efficiently packed in a hydraulic baling-press, whereas it is not practicable to have a powerful hydraulic press at a small ginery. Moreover, it is risky to gin in small gineries and then convey the lint in lightly pressed bales to a central baling factory, for the lint becomes stained and damaged through exposure; but once the lint is efficiently baled it will stand a good deal of exposure without suffering serious damage. Spinners do not like small bales of cotton, and the charges for handling them are higher in proportion than for large ones. Experience has therefore shown that in most cases it is better to incur the increased expense of conveying the seed cotton to a central ginery.

Marketing Cotton.—The purchase and sale of practically all growths of cotton, excepting Egyptian, are still based on American cotton; and for much of the information in the following account of the marketing of American cotton I am indebted to an article on this subject contributed by the Secretary of the Liverpool Cotton Association to *The Empire Cotton Growing Review*, vol. i. No. 2.

After his cotton is ginned and pressed, the farmer offers it on the open market in the town nearest to his farm, or

gives samples to "factors" who offer it on his behalf. Purchase is effected by representatives of the large European or American merchant houses. It is then despatched to the nearest steam compress to reduce the density of the ginnery bales. The houses which deal with British or Continental importers generally telegraph, from time to time, information as to the grades of cotton which they have to offer, and also the basis of price at which they are willing to sell.

When sales are effected, the exporter arranges with the local railway agent for railway and ocean freight accommodation for the transport of his cotton to Europe. When the railway agent receives the cotton, he delivers to the exporter a through bill of lading, which gives particulars of the number of bales and weight of the cotton. The bill of lading is negotiable and the exporter is able to reimburse himself in the terms of his contract with his purchaser. Usually he draws a sterling draft for the invoice amount upon the European bank, with whom the buyer has opened a credit for the purpose. Drafts of this nature are generally payable in London at sixty or ninety days' sight. The exporter then attaches to the draft the bill of lading, insurance certificate, and copy of the invoice; these, together with a sight draft on a New York bank which has purchased his foreign draft, he tenders to his local banker, and receives in dollars the value of the cotton exported. The draft is accepted by the drawee under written instructions from the purchaser, whereby the latter authorises the bank to retain the documents attached to the draft as security, and guarantees their validity.

The bill of lading is delivered by the bank to buyer, in order that he may take delivery of the cotton from the ship, and the latter undertakes to warehouse the consignment in the bank's name and to hand the warehouse receipt to the bank. When the buyer sells the cotton, he procures a warehouse release from the bank, in order that he may deliver the cotton to his purchaser; in return for which he undertakes to pay the bank the proceeds when received.

In the event of the accepted draft maturing prior to the sale of the cotton, the buyer may obtain a loan from the accepting bank for the purpose of retiring the matured draft, in which case the bank would retain the bill of lading or warehouse receipt as security. The sound financial stability

of Liverpool importers frequently enables them to finance such operations without the aid of a bank.

It will thus be seen that both the farmer and the exporter are able to procure cash for the cotton which they sell, and also that the European importer need not pay for the cotton until he has sold it and received the proceeds.

Having presented his bill of lading to the shipping company, the importer receives in exchange a delivery order. The cotton is landed and weighed by the master porter, generally under the supervision of a representative of the importer. If the importer has sold the cotton on c.i.f. terms, he need not take delivery, but instead hand over the bill of lading and insurance certificate to the spinner or spinner's broker, upon whom devolves this responsibility and of defraying the landing charges. When the importer sells his cotton for delivery ex quay, he is responsible for landing it, after which it is delivered to the buyer or the buyer's agent.

The Lancashire spinner usually buys his cotton through a buying broker; the latter acts as the former's agent in generally watching over the spinner's interests, in supervising the quality of the cotton purchased, and in forwarding it to the mill.

In the case of the arrival of cotton which has not been sold, the importer takes delivery and sends it to the warehouse. Samples are despatched to the importer's saleroom, and these are carefully selected and classified into respective lots according to marks or grades. Unless the cotton is destined to fill contracts made for deferred delivery, it is presented for sale on the samples, which are submitted to the representative buying brokers of Lancashire spinners.

The spinner, through his broker, is generally afforded an opportunity to buy at the cheapest possible price, for there is usually held in Liverpool a large stock providing a wide selection. As there are a large number of importers of this stock concentrated in the Liverpool market, keen competition to sell is engendered.

Sales may be effected on "spot terms", "arrival terms", or "deferred delivery terms". In the case of "spot terms ex warehouse" the buying broker arranges the despatch of the cotton to the spinner's mill, and settlement must be

effected by the spinner within ten days from the date of the invoice.

The spinner purchases ahead for delivery over a certain series of months in an endeavour to secure in advance the quality that he requires, in anticipation of the sales of yarn that he expects to make in that period. Consequently, in buying cotton for deferred delivery, it is to his convenience to buy it "on call", or, in other words, that while he fixes the basis in relation to "futures", the price is not fixed until the cotton is called, for the call is based on the price of "futures" at the time of fixing for the month within which the delivery is to be made.

It sometimes happens that the importer has made sales before it is possible for him to buy the cotton from the American shipper; in these circumstances he selects what he considers a suitable time to cover himself, and then makes his purchase, either at a fixed price or "on call" terms. When such purchases are made "on call" terms, it is customary for the shipper to have the right to defer the calling of the cotton until the time of shipment.

It is important to observe that the circumstance that large stocks of cotton are held in English warehouses, principally in Liverpool, enables European spinners to select the exact cotton that they require, by merely sending their representatives to the salerooms to inspect the wide variety of samples exhibited.

Until the machinery for marketing the crop had reached its existing high standard, it was customary for a considerable proportion of the American crop received in this country to arrive on consignment, for sale on behalf of the American consigner, the English broker receiving a brokerage for his service. To-day the practice is much less general in England, except when American merchants experience a lack of demand for the stocks which they are carrying. The extent of this practice is likewise influenced by the relative values of "futures" in Liverpool and New York, and the "near" and "distant" deliveries in the Liverpool market. For example, the selling of "distant" deliveries in Liverpool at a premium over "nears" presents an inducement to consign, as the premium affords assistance to the consigner in meeting the cost of freight and other charges to Liverpool.

Conversely, when distant positions are at a discount, they present an unprofitable hedging position and consignments are discouraged.

Such consignments have also been sent from America to some of the important Continental markets. Owing to the wide fluctuation in currencies, Continental spinners have frequently found it necessary to buy their requirements from the stocks in their own ports, and to meet this demand American merchants have been encouraged to make considerable consignments to these markets for sale through their agents to the spinners. By this procedure the Continental spinner is protected from the risk associated with exchange fluctuations, which thus falls on the merchant or the shipper.

Liverpool Cotton "Futures" Contract.—The prices ruling for "futures" govern the market price of raw cotton all over the world. The purpose of the Liverpool Cotton "Futures" Contract is to protect merchants, manufacturers, and others engaged in the industry against violent fluctuations in price, for by its means they can insure themselves against both appreciation and depreciation by buying or selling cotton for future delivery to the weight of their forward commitments.

All contracts are subject to the Articles and Bye-laws of the Liverpool Cotton Association. The cotton must be delivered in Liverpool during the month for which the contract calls. A spinner who is desirous of buying a certain quantity of cotton each week for several months ahead is able, by fixing the price of his yarn sold for the same period, to buy a similar weight of cotton for future delivery during the months that it is required. Having based the price of his yarn on the price that he could buy his cotton for future delivery, he is independent of price fluctuations; for as each month arrives he can sell out his future delivery contract and at the same time purchase the particular grade of cotton that he requires. If there is any advance or decline in market prices in the meanwhile, a proportionate profit or loss is reflected in the sale price of his "futures" contract.

In a similar manner, import merchants "hedge" to protect themselves against price fluctuations by selling an

equal weight of "futures" at the time they purchase their cotton. Free trading is provided by the presence of professional operators, jobbers, and dealers, who buy when they consider the market is too weak and sell when they consider it is too strong.

Fluctuations are based on pence and hundredths of a penny per lb. The Liverpool Cotton "Futures" Contract calls for 100 bales of 48,000 lb. weight of American cotton.

In the past, "future markets" were taken advantage of by speculators, so a check was put on their operations, both in Liverpool and in New York, by the establishment of clearing houses for the purpose of settling differences for "futures" once a week in Liverpool and daily in New York; the object being to guard against speculators overstepping the limits of their finances by compelling them to pay differences in cash.

Attempts that were made in the same markets to corner a particular grade of cotton were met by making the contract for "Middling" as wide as possible, delivery of any of the seventeen grades from "good ordinary white" to "fair" being permitted. The cornering of any one particular grade is prevented, as the difference between these two qualities has been fixed in New York at 385 points; a point is $\frac{1}{100}$ d.

The rules of the Bremen exchange contain a "mutual allowance" clause, under which Indian cotton can be bought and sold if mutually agreed upon by the buyer and the seller. A similar clause is also included among the alternative conditions in the form of contract on which Indian cotton is sold in Liverpool. By this clause, for a consignment that is slightly above standard, a seller can claim an allowance which is agreed upon between him and the buyer at the time the contract is made. On the other hand, if the cotton is below standard, the latter has the option of total rejection.

At a meeting in July 1925 the Liverpool Cotton Association adopted the "Empire and miscellaneous cotton delivery contract"; this is a new form of "futures" contract against which all growths of cotton not lower than the grade and value of strict low "Middling American" cotton may be tendered, the contract only excepting certain grades

of Egyptian cotton tenderable on the present Egyptian "futures" contract.

Growers and importers of British Empire cotton are thus provided with a "hedge" in the "futures" market, which should benefit Empire cotton growing.

CHAPTER XIII

COTTON FROM THE MANUFACTURER'S STANDPOINT

Spinning processes: Bale breakers—"Openers"—"Scutchers"—"Carding" machines—"Combers"—"Drawing-frames"—"Fly-frames"—Spinning—The "ring-frame"—The "mule"—Working economy. Defects in the material: Importance of even staple—Immature fibres—"Nep"—Twist and strength of lint—Evenness of grade—Impurities. Weaving. Mercerising. "Artificial silk." The properties of cotton: Lint development—Composition—The extending uses of cotton.

UP to the present our attention has been chiefly devoted to the study of cotton from the grower's standpoint, but, as the ultimate destiny of the cotton crop is the mill, it is advisable to consider the matter from the manufacturer's standpoint as well. Co-operation between the grower and the manufacturer is obviously advantageous to all concerned, so the grower should have a proper understanding of the manufacturer's requirements, and for this purpose it will be helpful briefly to review the various processes to which cotton is subjected in the spinning mill.

SPINNING PROCESSES

According to A. J. Turner (*Empire Cotton Growing Review*, vol. i. No. 2), on reaching the spinning mill, bales of cotton are first subjected to various processes which have for their chief object the opening up of the hard, matted blocks of cotton formed during the pressing operation, and the removal of foreign matter.

Bale Breakers.—Various types of bale-breaking machines are in use. By the modern hopper bale breaker, steel spikes penetrate the blocks of cotton and break them into small lumps. The spikes also penetrate the latter and facilitate their further breaking up and subsequent treatment.

“*Openers.*”—“Opener” machines next come into operation, by which tufts of cotton are beaten against grid bars. These machines deliver the cotton in the form of a lap similar to a thick, soft sheet of felt, which is wound round a rod as it emerges.

“*Scutchers.*”—Several of these laps, generally four, are put together by the “scutcher” machine, with the object of reducing their irregularity, and the fourfold lap is then subjected to a bladed beater action.

“*Carding*” *Machines.*—The “carding” machine completes the disentanglement of the fibres, and at the same time eliminates a great deal of the remaining dirt, short and weak fibres, and “neps”. “Neps” are the small tangled coils or knotted hairs in lint, about which more will be said later on.

The lap discharged from the scutcher is fed at one end of the card. A coarse, saw-toothed cylinder removes tufts of cotton from the lap, and these tufts are passed between two carding surfaces covered with finely tempered wire points set at an angle, and at the rate of some 500 to 750 points to a square inch of surface. The two carding surfaces move in opposite directions and have the wire points opposed, so that the fibres of a tuft of cotton are rapidly separated from one another. The cotton is delivered from the carder in the form of a continuous rope of fibres, which is known as the “sliver”.

“*Combers.*”—In the case of superior grades of cotton, a combing operation is next practised. The machine may be set to comb any length of fibre. If it is set to work, say, $1\frac{3}{16}$ inch staple, most fibres below this length will be combed out as waste.

A lap about 10 inches wide is prepared from the slivers, and a series of combs of increasing fineness is passed through the lap. This still further eliminates short fibres and neps, and results in a sheet of fibres which is again reduced to a sliver, in which the fibres are laid in a more parallel position.

“*Drawing-frames.*”—“Drawing-frames” now come into operation to obtain more regular slivers by passing the carded or combed slivers between four pairs of weighted rollers. As each successive pair of rollers revolves at a greater speed than the previous pair, the cotton is nipped

in turn by each pair and the sliver is drawn out. Six slivers are passed through the rollers at a time and each is reduced sixfold in cross section. They are then combed together so as to form a new sliver having a similar dimension in cross section to the original slivers, and this operation is repeated several times.

“Fly-frames.”—“Fly-frame” machines are now brought into requisition, in which the operations resemble those performed in the preceding machines, and are chiefly designed to effect, in successive stages, a reduction in the diameter of the sliver. In this case slivers are passed between three lines of rollers that revolve at increasing speeds, but for convenience of handling the material is given a twist and is wound on to a bobbin. As discharged from the first series of fly-frames the material is distinguished as “slubbing”, that from the second or intermediate stage as “intermediate roving”, and that from the third and final series as “roving”.

Spinning.—The material is now ready for the final spinning process. Three lines of rollers further reduce its cross section to the amount required, and the twist is inserted either by the “ring-frame” or the “mule”.

The “Ring-frame”.—The “ring-frame” derives its name from the flanged steel rings that encircle the bobbins mounted on spindles. A small piece of steel wire, known as a “traveller”, is sprung on the flange of each steel ring, and the roving as it issues from the last line of rollers of the fly-frames is passed down under the traveller and then on to the bobbin. A tension of the yarn is caused by the bobbin revolving at from 8000 to 10,000 revolutions per minute, and this drags the traveller round the ring at a rather slower speed than that at which the bobbin is revolving. The speed of the traveller determines the amount of twist inserted and the rate at which yarn is wound on to the bobbin, so that twisting and winding proceed simultaneously.

The “Mule”.—In the “mule”, many vertically inclined spindles are mounted on a carriage that has a to-and-fro motion; these spindles revolve at from 10,000 to 12,000 revolutions per minute. The roving is delivered to the carriage on its outward motion, and the rapidly revolving spindles insert twist, while during the inward motion of the

carriage the revolving spindles cause the winding of the yarn that was spun on the outward motion of the carriage. Owing to highly efficient mechanical control, the tension exerted during the twisting and winding can be regulated to a fine degree in accordance with the type of yarn being spun.

As about three-fourths of the total time required in the process of mule spinning is occupied by the outward movement of the carriage, when twist is being inserted, it follows that with a given spindle speed the output is accelerated when less twist is inserted. Soft-twisted yarn can therefore be spun more expeditiously than hard-twisted yarn. Further, as coarse yarn requires fewer turns of twist per square inch than fine yarn, both the weight and the length output of the former yarn is greater than that of the latter, and the same remark applies to the output of the ring-frame.

It is not usually practicable to spin weak and very fine yarns on the ring-frame, because in this process considerable tension in the yarn is exerted. This disadvantage does not attach to the mule-spinning process, and it can be adopted for spinning yarns that have the soft, full character desired for "weft" and the comparatively hard-twisted yarn required for "warp". These two types of yarn will receive further mention under "weaving".

Working Economy.—Economy of working demands that the daily output of bale openers, scutchers, cards, combers, fly-frames, and spinning frames respectively shall be the same for each. Such an adjustment is feasible for the production of a particular type of yarn from a *definite type of lint*, but it is obvious that any alteration in one or both of these two factors will affect the balance that should exist between the different machines. The original type of cotton has probably been spun to its finest limit consistent with the maximum permissible number of breakages; if an inferior type of cotton be introduced, an excessive number of breakages will occur on the mule or ring-frame, and not only will a lower quality of yarn be produced, but a smaller output and a larger amount of spinning waste will result. As the output of a coarse "count" of yarn is greater than that of a finer yarn, the difficulty may be overcome to a certain extent, as far as economical working is concerned,

by speeding up the machinery in order that the operation of the spinning frames is not delayed for lack of roving.

Cotton yarns are said to be of 20's, 30's, 40's, etc. counts when not more than a like number of hanks, of 840 yards, go to the pound avoirdupois, *i.e.* the higher the count the finer the yarn; 30's are yarns of such fineness that $30 \times 840 = 25,200$ yards weigh 1 lb.

Each mill projects to produce a limited range of counts from a given staple, and there are broadly five classes. In Oldham these are classified as: thick, coarse, medium, medium-fine, or fine mills. The thick trade produces up to 10's counts, and uses short staple or cotton waste. The coarse trade carries up to 22's, and the cotton is chiefly Indian, ordinary American Upland, or one of the new growths of recent years. The medium trade spins up to 46's, and uses "full" $1\frac{1}{8}$ to $1\frac{1}{4}$ inch American, Upper Egyptian, and East African cotton. The medium-fine trade produces yarns of 46's to 80's, and generally uses Egyptian cotton, but not Upper Egyptian, and in some cases Sea Islands. The fine trade carries spinning from 80's to the limit that the lint permits, sometimes as high as 400's and occasionally even to 700's.

It is possible to arrange a mill to spin every class of cotton, and, by changing the cotton, roller settings, and speeds at various processes, to produce any desired range of counts with the exception of the superfine. This can, however, only be accomplished by the sacrifice of competitive efficiency, which, in view of the keen competition in the cotton trade, is obviously not desirable.

DEFECTS IN THE RAW MATERIAL

Whether a manufacturer plans to produce a high- or low-grade yarn, he concentrates on producing as cheaply as possible, consistent with efficiency, and to produce the same characteristics regularly. He obtains the best results, with a minimum of labour, if the lint is: (1) of even length, (2) mature, (3) of even grade, and (4) free from impurities.

Importance of Even Staple.—For a yarn to be uniformly round and of maximum strength, it must have an equal number of fibres twisted together throughout its length, and

this is only possible when the staple of the lint is uniform. In the course of spinning, the sliver or rope of cotton is drafted by transmitting it to machines that ensure that an equal number of fibres are travelling forward together, gradually reducing the thickness of the sliver and the number of fibres in the cross section, until the correct count is reached. The drafting machines cannot accomplish this object successfully if the lint fibres are uneven in length. Of the machines used in this process, the comber is the only one that functions as a cleaner and a selector of fibre length, but with a consequent waste of material. Even it has not great value in this regard for lint below $1\frac{1}{4}$ inch, and in the case of longer lint only for eliminating fibres below a given measurement, and passing on those above this minimum. The functioning of the machines therefore precludes the manufacture of a perfectly level, even thread if uneven lengths of cotton are handled together.

Lack of uniformity in lint staple is generally associated with the growing of different varieties of cotton mixed together in the same field. When it occurs in the case of cotton grown from pure races, it is generally attributable to the mixture of successive pickings at different periods of the season.

Lack of uniformity in lint staple may also be due to careless ginning. Gin-cut staple results from the saws revolving at too high velocity, too tight brushes, and damaged saws. The United States authorities recommend the speed of saws, under average conditions, at 400 revolutions per minute for 10-inch saws, and 333 revolutions per minute for 12-inch saws.

Immature Fibres.—Indications of immaturity are soft, flat, ribbon-like fibres with a lack of natural twist, which is the basis of considerable trouble to the spinner. Immature lint gets broken up in the cleaning processes. Weak and broken fibres often get rolled into knots and form the “neps” about which much complaint is made.

“*Nep.*” —“Nep” is a common fault with many cottons. The term is applied to the small tufts of imperfectly formed fibres that occur in lint, and which cannot be properly straightened out, even in the carding and combing operations. Nep is a serious defect, because it is exhibited in the finished yarn as a

thick, soft place, which is always a weak spot. Neppy yarn is absolutely unfitted for "warp", and in "weft" it is seen on the surface of the cloth, for even in the dyeing process it causes the cloth to take up the dye unequally.

Weak fibres that are not eliminated depreciate the strength of the roving and yarn, and are conducive to labour troubles, for wages are based on production.

Nep and weak fibres are probably due to the imperfect nutrition of the cotton plant.

Twist and Strength of Lint.—Mature cotton, that has plenty of natural twist, permits workers to run machinery at maximum speed, and with a minimum of added twist, which is to the advantage of the employer and employee alike. Except for the natural twist or convolutions of the lint it would be difficult to spin because it is smooth on the surface. Generally speaking, the smaller the diameter of a cotton hair the larger the number of twists present. The twists do not exist as complete revolutions in one direction, but sometimes in one direction and sometimes in another. The twist is not uniform in different kinds of cotton—for example, in the lint of *G. brasiliense* it is less spirally twisted than is generally the case, and it resembles lint that has been mercerised or otherwise chemically treated.

The importance of twist is demonstrated by the fact that yarn strength is primarily dependent on the hold which the fibres take upon one another, and the slipping of fibre on fibre is more responsible for yarn breakage than from fibre rupture; for fibre strength as determined by the breaking strain does not greatly affect the strength of the yarn spun from it. In this connection, however, it is to be observed that the longer the individual fibres the less chance there is of several ends occurring at a particular point in the yarn and the creation of a weak spot where breakage is likely to take place. Again, for a given diameter of yarn, its strength will, within limits, be greater with the more fibres of which it is composed, so that fineness is another important factor.

The spinner's use of the term strength as applied to lint may include flexibility, amount of twist and length, or the possession of qualities which permit of the spinning of a strong yarn. Actually, as we have already seen, the strength of the cotton hair depends on the regular deposits of layers

of internal thickening in the process of ripening, and it is conceivable that any check in the plant's development, such as that caused by malnutrition, has an adverse influence on the acquisition of strength, and also on the length of the hair. Moreover, influences that affect boll shedding likewise have similar adverse effects on the hair.

Evenness of Grade.—Unevenness of grade or colour is disastrous to that section of the trade that aims to produce a standardised cloth or natural colour fabric, or one which it is intended to be finished in a particular colour. It is therefore comprehensible why, on certain occasions, perfectly graded lint has realised a high premium, although it had no pretensions to staple length. Provided that spinners and manufacturers are informed some time ahead that lint will be a particular colour, they can make the necessary adjustments, but sudden alterations in grade necessarily cause confusion, even though the alteration may not affect the quality of the yarn as regards strength.

Impurities.—The impurities found in cotton bales are of a varied nature, and range from leaf, stem, seed, “bearded motes”, fibres other than cotton, and excessive moisture to sand, stones, and iron. The last three pass into the machinery at the mill and cause much damage and occasionally fires as well. “Bearded motes” is the name given by spinners to small pieces of broken seed with fibre attached. All these defects are capable of elimination if due care be observed by the grower and the ginner.

WEAVING

Cotton yarns are mostly used in the manufacture of cloth, hosiery, lace, and sewing cottons, but by far the greatest part are used for cloth. The properties of cloth are generally judged by its appearance and its service, and the consumer estimates these properties by the feel and the actual appearance of the cloth to the eye. Generally, what is desired is a firm, closely woven fabric that feels soft but full and has a certain weight. Although modern technique in “finishing” cotton cloths renders it possible to make poor materials look like good ones, it nevertheless requires good quality yarn to produce good quality cloth.

In the manufacture of yarn into cloth, it passes through processes known as winding, warping, and weaving. It is obviously desirable that the yarn should be spun in such a manner that it is damaged as little as possible in the course of these processes; the possibilities of the greatest damage are experienced in weaving.

Cloth is woven in long lengths and of a given width by interlacing two sets of yarns at right angles to one another. The yarns that run lengthwise are "warp" yarns, while those that run crosswise are "weft" yarns. A strong yarn is required for warp, but this is not necessarily the case for weft. In the course of weaving the warp yarns may be severely strained, frequently even to breaking point, whereas the weft yarns are only subjected to slight tension and thus rarely break.

The warp yarns are held in the loom at great tension and in a horizontal plane. A "shed" is formed by raising some of the warp yarns relatively to others, and a shuttle passes through this "shed" and leaves behind a trail of weft yarn. The warp yarns are drawn between the teeth of a comb-like reed, which receives a to-and-fro motion. The shuttle is passing through the "shed" when the reed is in its rear position, but it then comes forward to "beat up" the weft yarn left behind by the shuttle. The rapidity of the motion may be judged when it is stated that as many as 200 weft yarns may be inserted in a minute.

In its movements the reed rubs against the warp yarns drawn through it and tends to weaken them, while additional strain is imparted to them by lifting them to form a "shed".

Mercerising.—In 1844 John Mercer discovered that when cotton is immersed in a solution of caustic soda various structural changes take place, the most important result being that the fibres are given a silky lustre. Improvements in the manufacture of cotton goods by this process enable fabrics to be turned out so fine in texture and glossy in appearance that they closely resemble the finest silk.

"Artificial Silk."—Strictly speaking, the material which passes for "artificial silk" is not silk, although it is certainly artificial. Both the textile trade and the general public have long realised the necessity for a name that would express with some degree of accuracy the character of this material.

In America attempts have been made to establish words such as *rayon* and *glos*. In 1924 the word *rayon* was adopted by the textile trades in the United States, and subsequently it was endorsed and used by the Silk Association of Great Britain. In this country, however, the use of this word has received little support, and, moreover, one of the leading manufacturing firms of artificial silk declare that their product is not *rayon*.

The growth of the artificial silk industry is without parallel in the world's textile industries. In 1909 the world's output of artificial silk was about 7500 tons. In 1925 it amounted to 87,000 tons; the United States was the largest producer with 22,300 tons, Italy was second with 13,400 tons, and Great Britain third with 11,150 tons. The estimated output for 1926 is given as 100,000 tons. The demand for the material is greater than the supply, and there appears to be little probability of the supply overtaking the demand in the near future. The total amount of capital invested in the industry is estimated at £88,000,000, of which more than £30,000,000 are invested in the British section. This progress is all the more astonishing when it is borne in mind that it has reference to a new trade which has not ousted an old one.

Cellulose in some form or another is the raw material from which all artificial silk is manufactured, and although it forms the major portion of all vegetable fibres, only those obtained from cotton and wood-pulp have been used commercially in this connection, while the latter is generally chosen on account of the plentiful supply and low cost. The wood which produces the most satisfactory cellulose for this purpose is that of the spruce, a coniferous tree which occurs in extensive forests in North America, Finland, and Scandinavia.

It is in connection with the use of cotton and cotton linters for artificial silk manufacture that the cotton-grower is chiefly concerned. When cotton is used as a basis for artificial silk, it has been found to impart a greater tensile strength to the finished product, and it is therefore in greater favour for use as warp or twist. The breaking strain of artificial silk with a cotton basis is about 25 per cent higher than that of artificial silk produced from wood-pulp; consequently there is special concentration on the production of the higher grades with cotton, mostly in the form of linters,

as a base. Prepared wood-pulp costs approximately 2d. per lb., whereas linters cost about 5d. per lb., and, moreover, before they can be utilised for artificial silk it is necessary to extract, by a bleaching process, all fat, wax, and natural colouring matter before they can be regarded as in any way equal to wood-pulp. There is an abundant supply of wood-pulp, but the supply of cotton is limited, and its use is mainly restricted by financial considerations. That artificial silk is being extensively manufactured from wood-pulp to-day is chiefly due to the economic pressure brought about by the shortage and the price of linters.

It is well recognised that if the artificial silk industry is to continue to thrive, the production, at the cheapest possible rates, of absolutely first-class tissues in colouring, texture, and strength is essential, and linters are undoubtedly an important factor in this connection. This demand, therefore, appears to afford an opportunity for the cotton-grower in many countries to supplement his profits by delinting his seeds, for at the present time enormous quantities of cotton seeds with their valuable linters are either thrown away or are used as fuel.

There are four processes by means of which cellulose may be converted into artificial silk: (1) Chardonnet or Nitro-cellulose; (2) Cupra-ammonium; (3) Viscose; and (4) Cellulose-acetate.

The Chardonnet or Nitro-cellulose Process.—Sir Joseph Wilson Swann, of Bromley, Kent, produced artificial silk by this process as long ago as 1884, but Comte Hilaire de Chardonnet, a French scientist, invented the first process by which this material was produced on a commercial scale, and his products were first exhibited to the public at the Paris Exhibition in 1889. Except in Belgium it has now been almost entirely superseded by one or other of the other three processes. The nitro-cellulose process is partly chemical and partly textile, and its basis is cellulose derived from cotton linters. The cellulose is immersed in a solution of nitric acid, sulphuric acid, and water, and converted into nitro-cellulose. Although this nitration does not change the cellulose itself, its chemical nature is altered to such an extent that it has become soluble in different solvents, and, when it is placed in a solution of alcohol and ether, it is reduced to a viscous paste known

as collodion. The collodion is purified by filtration through various substances, of which the most important is cellulose wadding. The purified collodion is taken to the spinning machine, and is pumped or forced under high pressure through glass tubes, each of which has a capillary orifice as fine as 0.08 mm. The collodion issues from the tubes in the form of jets of viscous matter, from which the ether and alcohol evaporate as they come in contact with the air, and the collodion is transformed into fine filaments of nitro-cellulose. The filaments are grouped together, according to the count desired, and wound on bobbins.

In the milling room the bobbins of nitro-cellulose are placed on the spindle of a throwing machine, which revolves at the rate of several thousands of revolutions a minute, and so twists the filaments into a thread which is wound on another series of bobbins. In the reeling room the twisted nitro-cellulose thread is made into skeins. The thread is still nitro-cellulose, but the process of denitration now begins. The nitric acid is destroyed by immersing the skeins, suspended on glass rods, in a solution having as its basis sulphhydrate of ammonium, sodium, or calcium. The denitration bath completely changes the physical aspect of the threads, but they are restored to something like their original chemical properties. The tangled mass of linter fibres has been converted into long cellulose fibres, fine, regular, and silky in appearance. After being carefully washed and slightly bleached, the denitrated artificial silk yarn is dried by mechanical appliances and the skeins are graded and packed in bundles. The completed yarn is of a high quality; it is remarkable for its tenacity, which is higher, when dry, than that of other artificial silks. As with other artificial silks, in a wet state its tenacity is diminished, but in this respect it takes second place only to artificial silk produced by the acetate process.

The Cupra-ammonium Process.—Despeissis patented this process in 1890, but he died before the patent became valid, and his researches were continued and carried to a successful issue by Pauly in 1892. In this process the cellulose used is in the form of either bleached cotton linters or wood-pulp. The raw material is first treated in beating machines. Of the mass thus obtained every particle is forced into contact

with atomised copper hydrate, and it then passes into kneading machines where ammonia causes the solution of the cellulose, and a blue viscous fluid results. This after filtration is forced by pumps through orifices into a coagulating medium, where the solvent of the cellulose is decomposed and the separate filaments of cellulose are joined together to form a thread. The pumps are capable of adjustment, so as to enable the spinning machines to be set either for fine or coarse counts.

In what is known as the stretch spinning process, the solution is passed through comparatively large holes in the spinning nozzle, and as the filaments issue from the spinnet they are stretched as they pass through the slowly acting coagulating medium until they attain the requisite fineness.

The yarn is wound on reels, bobbins, or cheeses; if necessary it can be twisted by passing it into a cylindrical box that revolves at a high speed. As the material leaves the spinning department it is freed from all traces of chemical by being washed in various chemical baths and lastly in water; it is then dried and graded.

The Viscose Process.—The viscose process was discovered by two English chemists, Cross and Bevan, in 1892, in the course of their investigations of cellulose, which had been in progress since 1880. As in the last-mentioned process, both wood-pulp and cotton are used. Sheets of cellulose are submerged in caustic soda solution, which causes the fibres to swell and to produce what is known as “alkali cellulose”. The swollen sheets are subjected to hydraulic pressure so as to remove the excess of caustic soda. They are then passed through a grinding machine and disintegrated to form what are technically termed “crumbs”. The crumbs are stored in boxes for a few hours; oxidation takes place, the amount of which has a definite effect on the resulting viscose solution and likewise on the physical and chemical properties of the yarn produced. They are then treated with carbon disulphide in a churn, which reacts with the alkali cellulose, and results in an orange-brown gelatinous mass. This is dissolved either in a weak caustic soda solution or in water, and a pale, reddish-brown viscous fluid known as viscose is formed.

The viscose is filtered to remove air bubbles, unattacked fibres, dirt, etc., and it is then allowed to “ripen” for a

definite period of time, at a constant temperature. It is then ready for spinning, and it is fed under uniform air pressure to the spinning machines, and after passing through small measuring pumps it eventually reaches a platinum nozzle submerged in a suitable coagulating medium, known as the spinning bath. Each nozzle is perforated by a number of holes corresponding to the requisite number of filaments in the ultimate thread. The viscose issues from the orifices of the submerged nozzle in the form of continuous streams, and it reacts with the spinning bath, and is immediately converted into filaments which are composed of impure cellulose. The filaments are in a plastic condition, but they are sufficiently strong to be collected and twisted to give a useful textile thread.

Two methods of spinning are in use, one known as the bobbin or spool method, and the other the Topham box method; the latter is preferred by English and American manufacturers. After spinning, the yarn is washed in water to free it from acid. The fixation of the cellulose is completed by placing the yarn in stoves. The yarn is now dull, opaque, harsh, and stiff, and these defects are removed by treatment with sodium sulphide solution, followed by light bleaching. Further washing takes place to remove chemicals, and after being dried and graded it is ready for despatch to the manufacturer. It is considered that the viscose process is responsible for 75 per cent of the world's production of artificial silk.

The Acetate Process.—The latest artificial silk process is the treatment of cellulose with acetone. Cellulose-acetate was first prepared by Schutzenberger and Naudin in 1869; it was subsequently explored and developed by several investigators, but the Swiss chemist Henri Dreyfus was the discoverer of the process which has made the acetate filament a commercial possibility. Dreyfus took out his first patent in 1911. By this process filaments may be obtained from either cotton or wood-pulp by treatment with acetic anhydride and a catalyte. The cellulose-acetate thus formed is precipitated as a white spongy mass by placing it in water. This spongy material after being washed and dried is dissolved in acetone, which produces a viscous fluid. Regeneration to cellulose is not necessary, and the filaments of acetate of

cellulose are spun from this fluid in a manner similar to that adopted for other cellulose yarns. Much economy of labour is effected by the use of this process; various operations associated with the manufacture of filaments by the other processes are eliminated, for once having solidified on the evaporation of the acetone by contact with the air, the acetate filament is ready to be combined in yarns of various weight and wound on bobbins ready for use.

Cellulose-acetate is substantially non-hygroscopic; fabrics made from it resist the action of sea-water better than any other known fabric, the tensile strength is high, and it is practically unaffected in a wet state; another notable characteristic is the individual fineness of the filaments. As regards dyeing properties, cellulose-acetate yarns have an affinity with their own special dyestuffs, which is not shared by other fibres or filaments, so that when they are mixed with, say, cotton or wool and dyed in the same bath, two different colour effects are produced, which is known as cross-dyeing.

At the present time the bulk of the artificial silk is used for the adornment of wearing apparel. It is not a competitor of the older natural fibres, for its great function is to render other textile goods more attractive and more readily saleable. It is thus complementary to cotton, although it has caused a slight displacement of mercerised fabrics. Artificial silk has almost revolutionised the lingerie trade, for it particularly appeals to a large class of the community who cannot afford real silk underwear. It is, however, doubtful whether it could stand entirely on its own intrinsic merit as a fibre of commercial importance, except on such a small scale that it would be of little importance to the textile industry, chiefly owing to its chemical composition, physical properties, and mechanical structure. Strange to say, it is because of these inherent properties and characteristics that it has found such favour with every section of that industry, for they comprise a high degree of lustre, richness, purity of colour, and a superior delicacy and refinement of filament, which render artificial silk more like natural silk than any other textile material. It thus follows that its immense possibilities for decorative treatment cannot be neglected by

the manufacturer of any class of fabric that requires such treatment.

One of the greatest hopes for the recovery of the cotton trade from the existing depression is therefore regarded by some authorities to lie to a great extent in the admixture of cotton and artificial silk. Having regard to the four great staple industries, *i.e.* cotton, woollen and worsted, linen, and silk, it is the cotton section which affords the greatest scope for the most effective display of artificial silk, for it has the largest volume of trade, and cotton fabrics are manufactured in a much greater variety of textures in which artificial silk may be introduced as a decorative feature and with the most pleasing artistic effect. In conjunction with cotton it may be employed in any combination, either as an all-cotton warp with all-artificial silk weft, or *vice versa*; also with either or both series of threads containing each of those materials in any proportion. One of the most recent uses to which artificial silk has been applied in conjunction with cotton, and which it is confidently anticipated will open up an immense range of possibilities in the future development of the cotton industry, is to cut the artificial silk into staple lengths of about $1\frac{1}{4}$ inch, and then blend it with the raw cotton staple and spin them both together.

No other textile is capable of being utilised for such a variety of purposes. It is successfully used for hosiery, gloves, frocks, underwear, linings, ribbons, shirtings, threads and cords, embroidery, knitting yarns, sweaters and jumpers, neckties, lace, curtains, furnishing fabrics, chiffon velvet, tapestry, reversible satins and marocains, serges, plush fabrics, and imitation furs. Outside the textile trades it is used for electrical insulation, filaments in incandescent globes and gas-light mantles, and a variety of other commercial purposes.

THE PROPERTIES OF COTTON

Lint Development.—After the cotton boll has opened and while the lint is ripening, the fibres lose their moisture, take on a more or less flattened form, and become irregularly twisted on their axes in a spiral manner. We have already seen that the cotton hair consists of a single cell and that it

grows to its full length during the first half of the period of the boll's development. During the second half of the period of boll development, secondary deposits of cellulose are laid down on the cuticularised primary wall of the cell ; but this process proceeds intermittently. Normally this deposit of cellulose is interrupted for a certain period each day, with the result that in place of a homogeneous deposit of cellulose a series of well-defined growth rings are formed within the primary wall, each of which represents one day's growth, and as many as thirty of these rings have been detected in one hair.

The secondary wall is traversed obliquely to the axis by simple pits, which are responsible for the twisting of the hair and its subsequent characteristic convolutions. Consequently, if for any cause there is little or no secondary thickening, so that the hair consists chiefly of primary wall, it will offer little resistance to bending strains. It is weak fibres of this nature that are the principal cause of "nep", for they are readily rolled into a tangled coil. Some kinds of cotton produce more nep than others, and those which produce an abnormal quantity should be discarded from cultivation. It should be observed that, except in the most humid regions, growth normally ceases for a period each day when the sun is shining, and is due to the transpiration of water at a greater rate from the aerial parts of the plant than it is being absorbed by the roots. It is in this manner that the growth rings of the lint are deposited. Obviously, then, the more humid the conditions of growth the less uniform will be the secondary deposit of cellulose, and the greater will be the production of weak hairs and neppy cotton.

Composition.—The properties of cotton which make it so valuable as a textile material are due to the chemical substance cellulose, which is its principal constituent ; indeed the cotton hair produces cellulose in its purest natural form. There are, however, certain other substances mixed with the cellulose, and for many textile purposes these by-products or impurities must be eliminated by treatment with chemical agents in the process known as bleaching. This chemical process is invariably injurious, to a certain extent, to the cellulose itself ; consequently the bleacher adopts the mildest

chemical process practicable for the purification of the cellulose.

The amount of impurities or minor constituents of cotton to be removed varies in different kinds of cotton, and hence the mildness or otherwise of the chemical treatment in bleaching. The presence of wax varies from 0.3 to 0.6 per cent, nitrogen from 0.2 to 0.4 per cent, and phosphates from 0.05 to 0.1 per cent. Wax occurs on the surface of lint, and hence it is unable to absorb water readily. It is not known whether certain bleaching processes remove the cuticle, or how its presence or absence affects the dyeing, lustre, feel, and weaving properties of fabrics.

The melting of the cotton wax constituents influences spinning, for it is commonly assumed that it becomes plastic above some fairly definite working temperature; this circumstance permits the cotton to work easier because of increased pliability, and may even function as a lubricant. The wax dissolved from cotton by benzene has been found to have for its principal constituent a solid alcohol, which has a melting point of 187° F. The wax, however, contains a large number of ingredients, and the whole mixture melts at 158°-167° F. The wax does not melt at ordinary room temperatures, but it may become softer.

The presence of the inner canal of the cotton hair adds to its absorptive capacity for fluids; its capillary action permits the fibre to retain dye-stuffs and salts, though its principal capacity in this respect is due to the presence of minute pores on the walls of the fibre. This is shown by the circumstance that mercerised cotton is more absorbent of dyes than ordinary cotton; for when cotton is mercerised, the inner walls are pressed against each other so that the inner canal is almost obliterated.

It must not be presumed, however, that the same dye-bath will dye all kinds of cotton alike, nor will the same results be secured in lustre-producing processes, such as calendering, mercerising, and schreinerling. For example, Egyptian cotton has an excellent capacity for dyes and high lustre, which make it valuable for mixing with silk and fabrics that require a brilliant finish, while its natural *écru* shade is preferred in certain articles.

THE EXTENDING USES FOR COTTON

Factors that have affected the more extensive demand for cotton are progress in textile equipment that call for larger supplies of raw material, and the greatly increased employment of cotton for industrial purposes other than for wearing apparel.

Until fifty years ago the uses of cotton for purposes other than clothing were of negligible proportions and were mainly confined to the manufacture of heavy-weight cotton "ducks" for the sails of ships, tents, and tarpaulins. Cotton became so abundant and cheap during the price-depression period of the 'nineties that it began to replace other products, and its introduction to various industries proved so satisfactory that it has never been ousted; indeed in certain cases new uses were discovered for it and for which no substitute has been found.

Cotton alone, or rubber with a basis of cotton, has largely replaced leather for belting. Cotton bags have replaced barrels in many industries, such as cement manufacturing. The low price of cotton enabled it to compete with the mounting price of wood. Not only has it been able to compete successfully with leather, wood, rubber, flax, jute, and hemp, but even with steel. Feeding-bags for horses have been made entirely of cotton, and cotton baskets have taken the place of wooden buckets for the delivery of household coal. Cotton proved to be the best material for filters in the petroleum industry, while cotton belts for drying pulp have been introduced into the pulp paper manufacturing industry. Large quantities of cotton are now consumed for the belt conveyors that eliminate the handling of products in large commercial establishments, and in the larger post offices. Large quantities of cotton, and especially Egyptian cotton, are used in the manufacture of motor-car tyres. Some idea of the extent of the demand for cotton in this connection may be seen when it is stated that the United States alone turns out approximately 50 million tyres a year.

Railway companies are big users of cotton for air-brake hose, fabric for railway seats and cushions and the enamelled ceilings which, in many cases, are highly finished, and enamelled cotton cloth. It is estimated that the United States motor-car industry requires half a million bales of

cotton annually for the manufacture of artificial leather upholstery and tyres. Millions of yards of cotton "cheese cloth" are used annually for providing shade for tobacco cultivation. The large screens used for advertising purposes are frequently made of cotton.

Quite apart from its well-known use in connection with the manufacture of high explosives, to-day cotton takes a place only inferior to chemicals, copper, and petroleum in warfare, by providing the raw material for clothing, sandbags, tents, tarpaulins, etc.

Subjected to chemical processes, cotton is employed in the manufacture of an extraordinary variety of substitutes for other raw materials under such names as "Pyralin" and "Fabrikoid," such as amber, bronze, copper, ivory, tortoise-shell, leather, and rubber. Chemically treated the product is used for coating for split leather, hides, for upholstery, travelling bags, artificial leather, fibre boards, to make them waterproof and to give them a leather-like appearance, gas mantles, and many other purposes too numerous to mention here.

Cotton is converted into nitrocellulose or gun-cotton by treating it with a mixture of nitric and sulphuric acids. Collodion is obtained by dissolving nitrocellulose in ether or in a mixture of ether and alcohol. This product is used for closing wounds, in the manufacture of photographic plates, celluloid, and other purposes.

CHAPTER XIV

THE IMPROVEMENT OF COTTON

Pure seed and lint uniformity—Bulk selection of seed—Cotton improvement by a commercial firm—Single plant selection—Importance of purity and its maintenance—Mutants—Dr. Webber's method of selection—Plant selection in practice—Isolating constituents of a mixture—Hybridisation—Factors affecting improvement.

Pure Seed and Lint Uniformity.—Having regard to what has been said in the preceding chapter as to the characters of cotton that are most desired by the manufacturer, it will be useful to consider what measures the grower can take to improve his product, so as to make it comply with the manufacturer's requirements, and at the same time render it more profitable of production.

Assuming that the grower has decided upon the type of cotton which it is most profitable for him to cultivate in the particular locality in which his farm is situated, it obviously will be to his advantage to secure the profitable production of the greatest possible yield of cotton of the highest possible quality of this type.

As we have already seen, a uniform quality of lint cannot be obtained by planting mixed seed, nor can uniformity in a particular variety of cotton be maintained unless it is grown isolated from other varieties of cotton, owing to the plant's tendency to hybridise. It thus follows that the production of the best and most uniform lint in a particular district can only be maintained when cultivation is limited to a single variety so as to avoid mixture of seed in the gins and crossing in the fields. Where the cultivation of a pure variety is impracticable of isolation, the maintenance of the purity of the variety can only be secured by the continual raising and issue of pure seed from a central station.

The key to the problem of uniformity desired by the spinner is thus to be found in the cultivation of pure cotton, for the fallacy of the theory of degeneration, which is commonly attributed to an inherent plant character giving to a particular type a limited span of life, is demonstrable by adequate protection from cross-fertilisation.

Bulk Selection of Seed.—In cases where the seed is known to be mixed, much good may be done by practising what is known as “bulk selection”. This consists of selecting seed for planting from the best seed cotton produced in the field. It is a rough-and-ready method of improvement, and can have little lasting benefit, as no attempt is made to separate the seed of different varieties, nor is hybridisation checked.

Another form of selection of this nature consists of collecting seed for planting from plants in the field which appear to possess the characters that the grower desires to perpetuate. Although this is an improvement on the previous method, it is impracticable to ensure that all the plants selected will be true to type, while a great number of the flowers on the plants selected will probably have been pollinated, by insects or other agencies, with pollen from other types of plants in the same or adjacent fields.

Cotton Improvement by a Commercial Firm.—In the United States private enterprise has done much to improve cotton by selection and breeding. The Coker Pedigree Seed Co. of Hartsville, South Carolina, is one of the most widely known commercial firms engaged in this work. Webber cotton, which has proved so successful in Iraq and elsewhere, is one of its productions. The procedure practised by this establishment for the last twenty-five years may be briefly described.

Tests are conducted concurrently with selected strains of the same variety against strains of other leading varieties. In the first season, plant-to-row tests are made by planting the seed from a single plant in each row. From these five superior rows are chosen for further trial. In addition a few of the superior plants in each of these five rows are chosen for plant-to-row tests in the following year, and to form a new series of tests. The rejected plants are then removed.

In the second season, the five selections are grown in

larger plots, and are also grown in a general variety test plot. At the end of the second season two of these selections are discarded.

In the third season the remaining three selections are tested again in a like manner. At the end of the season two of the selections are discarded, the one retained being that which has demonstrated its superiority over all those first selected.

In the fourth season this selection is again tested, and a large plot is grown to supply seed for a general seed crop.

The whole procedure is thus a continuous one, for in the third and fourth seasons the selections will come into competition with later selections from the plant-to-row tests made in the second season. The result of this is that the selection of a certain season may be discarded for a superior selection of a later season.

It is maintained that the longer this continuous selection is practised, the better and more uniform the strain becomes. As accurate records are kept of every individual strain dealt with, it is possible to trace the ancestry or pedigree of any strain to the original plant first selected.

Single Plant Selection.—The method of cotton improvement by raising seed from a single selected plant has been largely adopted with a considerable degree of success. Many of the superior varieties of Upland cotton have been evolved by this method. Most of the best known varieties of Egyptian cotton originated in this way. In this manner great improvement has been effected in Sea Island cotton, both in the Sea Islands and in the West Indies. The whole of the Pima-Egyptian cotton grown in the irrigated South-West of America has been developed from a single plant selected from plants grown from seed that was originally introduced from Egypt. That the work is well worth while is demonstrated by the fact that the United States Department of Agriculture spent £10,000 in introducing, breeding-up, and establishing Pima-Egyptian cotton, and the value of the crop reached at one period £5,000,000 a year.

Importance of Purity and its Maintenance.—The deterioration and eventual abandonment of many of the best known Egyptian cottons has been largely due to cross-fertilisation in the field and the mixture of seed in the ginneries; but

of course it is quite conceivable that at least some of the selections were unstable hybrids.

That the deterioration of various Egyptian cottons has been due to cross-fertilisation and seed mixture is demonstrated by the greater purity of Ashmouni cotton. This is the oldest Egyptian commercial cotton, which has been grown almost exclusively in Upper Egypt for many years, where it has maintained its original characters, because it has not been grown in association with other types to any extent.

The high standard of Pima-Egyptian cotton has been maintained through the growers in a particular locality agreeing to grow the selected cotton exclusively. Moreover, as the cotton fields are rigorously scrutinised for aberrant forms, which are promptly eliminated, there is little danger from contamination in the field or ginnery. When Egyptian cotton was first introduced, the cotton matured very late in the season, in fact too late for it to be profitably produced, and it varied greatly in character. The plant eventually selected matures much earlier, is more prolific, and yields lint of a uniformly superior character.

Mutants.—It is quite conceivable that many of the plants selected in Egypt were mutants. Mutation may be defined as the appearance of a distinctly different individual, whose progeny exhibit the distinctive characters of the parent by self-pollination or by plants of the same parentage. It is useful to bear in mind that the selection of a new type of this nature, that appears spontaneously in the fields, is generally better adapted to local conditions, climate, and pests than newly introduced varieties, and the grower would be well advised to keep a constant watch for the appearance of such forms with the view of utilising them to improve his crop.

Dr. Webber's Method of Selection.—In connection with the preceding remarks, Dr. H. J. Webber, of California University, planned a system of continued selection for cotton improvement which is outlined in the following diagram. By this system a new and improved selection is made each year, and at the end of four years sufficient seed to plant the main crop is obtained of the plant originally selected. The continued practice of this system results in

the production and maintenance of cotton of a high standard of excellence.

	1st Year.	2nd Year.	3rd Year.	4th Year.	5th Year.
Select plant	(1) Select plant	500 plants (1) Select plant	5 acres 500 plants (1) Select plant	General crop 5 acres 500 plants (1) Select plant	.. General crop 5 acres 500 plants (1)

Plant Selection in Practice.— In the practice of plant selection a method which may be usefully adopted, briefly stated, is as follows.

In the first season a certain number of plants are selected and marked ; the produce of each is harvested separately, and only such lots as approach nearest to the desired standard are retained. This standard must not be fixed too high at the outset or disappointment will result. It is important to remember that the best plants in the fields are often hybrids and will therefore be found to produce mixed offspring.

In the second season, a separate plot is sown with the seed of each selected plant. The resultant plants are examined for purity of habit ; if impurity exists in this regard, representative plants of each type are noted and marked. Of the plants that are pure as to habit, a number of the best-looking plants are marked, and the flowers on them are self-fertilised. This is secured by covering individual flowers with fine netting or some material that will effectually protect them from interference by insects or other agents of cross-fertilisation. When the flowers are sufficiently developed they are uncovered and pollinated with their own pollen, and then re-covered until the bolls are set.

When the bolls mature, each plant is examined in the impure lots to see if any plants are worth keeping that were previously overlooked, also to see if lots pure for habit appear to be pure with regard to type of produce. If the latter are impure, the fact is noted and the selfed plants are examined to see if different types are represented. The produce of each marked plant is gathered separately and is critically examined, and as a result some may be discarded. As in the beginning, produce of single plants from impure lots is

kept separate, but the selfed seed from the marked plants and such lots as prove to be pure is mixed.

In the third season there is probably sufficient selfed seed of pure type to sow two sets of plots, one to produce pure seed, and the other to test the yielding properties of the pure cultures, both against one another and the original mixture. The pure seed is sown isolated from other cotton to prevent cross-fertilisation, and the produce of plants in the centre of the plot is gathered separately for seed sowing in the following season. The seed for the test plots is sown in long strips, side by side, in series repeated as many times as the seed at disposal permits. The produce of each strip is weighed, then ginned separately and the results recorded.

The process of growing pure seed on large plots and testing the yield is carried on for three or four seasons so as to eliminate seasonal variation effects, and probably some types are discarded as it proceeds. Of those that remain, the plots are increased in size until sufficient lint of each is obtained for a spinning test. From the results of this and the yield tests a final selection of one type is made for general use.

Isolating Constituents of a Mixture.—Instead of selecting likely plants, the mixture may be investigated until all the component types have been secured. Single-plant selection and self-fertilisation is then practised until all the types are obtained in pure cultures. From these a few of the best are selected and tested in the field and in the mill.

This procedure involves a careful study of the inheritance of all the various characters met with, even though some may have no apparent economic significance. It constitutes the first step of improvement, and is followed by the isolation of types and hybridisation, the ultimate aim being to select the type which possesses one or more useful characters in the highest degree, and by judicious crossing produce a type which combines in itself all the useful characters to the highest degree. The whole problem is most exacting and may involve, by re-crossing, the combination of characters of three or more races.

Hybridisation.—The process of developing new and improved types of cotton by hybridisation has been in practice for many years. The Dutch colonist Rohr, who lived at

Santa Cruz from 1786 to 1790, published in the latter year an account of the hybridisation processes that he employed.

Much of the work that has been done in this connection has been of a perfunctory and promiscuous nature, and in view of the impure nature of the stocks selected for treatment, the results have been in many cases far from satisfactory, so much so that many workers inclined to the view that it is impossible to effect lasting improvement of cotton by this means.

Examples of the difficulties associated with this work are shown by the circumstance that many attempts have been made to obtain new varieties, profitable of cultivation, by the hybridisation of Sea Island and Upland cottons, and of Egyptian and Upland cottons. In regard to the former, there seems to be no authentic record of such a hybrid having been definitely fixed. The practical results of the very extensive investigations conducted by the United States Department of Agriculture with the object of combining the desirable characters of the Egyptian and Upland cottons may be briefly stated in the following extracts from a report on the work: "It may be inferred from the results of this investigation that, although the data on correlation indicate relative freedom of recombination, the chances are heavily against the isolation and fixation of a productive type of cotton, combining the most desirable characters of both parents, from the segregation products of so wide a cross as that between Upland and Egyptian. It is also evident that accidental cross pollination between these cottons cannot but greatly impair both the uniformity and the fertility of either type. Both of these conclusions are in line with the practical experience of cotton breeders."

Although cross-fertilisation is readily effected between both Egyptian and Upland and Sea Island and Upland, and the first generation hybrids appear to be promising, no hybrid stock has yet been developed of a sufficiently uniform character to warrant planting on a commercial scale.

Factors affecting Improvement.—More recently, however, by the application of Mendel's Law, it has been found possible to extract pure strains, except for differences that are known to be due to the environment only, even from crosses between very dissimilar kinds of cotton. These have been shown to

breed as true, after two generations only, as if their pedigree had been pure, by fertilising plants under control and growing the progeny till a plant was found the offspring of which were all identical.

This work is, however, of a highly technical nature, involving much scientific knowledge and a considerable amount of patient labour; it is therefore best left to the scientific plant breeder. Much difficulty is engendered by the doubtful or unknown origin of many of the plants now in cultivation, so that importance attaches to the possibility of employing some of the known truly wild species for breeding purposes. It has not yet been accurately determined how many factors are concerned in the inheritance of such a simple character as length of staple, while our information is still more meagre as to the inheritance of factors affecting the strength and fineness of lint. Accurate knowledge of these factors as well as those affecting lint uniformity will probably not be acquired until a more extensive history of pure lines has been secured.

There is a close correlation between the lint and seed weight; a large quantity of lint is more likely to be produced on large seeds, as the bigger seed has more surface and can carry more fibres, always bearing in mind that there is a size of seed beyond which it would not be profitable to proceed. It is more beneficial to aim at a large quantity of lint per seed than for a high ginning out-turn, for there is a positive correlation between the weight of lint per seed and the weight of lint per acre, which is the primary consideration, for the ginning percentage, compared with it, is a minor consideration.

The production by a plant of a high proportion of fruiting branches and a low proportion of vegetative branches is an important factor affecting yield.

The mean maximum length of lint is known to be a hereditary character which is subject to environmental modifications, and even in a pure strain to fluctuation. The longest fibres are produced at the posterior end of the seed and the shortest at the anterior end. Experience has shown that ginning percentage and staple length are characters which vary independently and are not, as usually supposed, correlated.

Resistance to disease and pests is likewise a hereditary

character. Types have been isolated that are resistant to both Wilt disease and Angular Leaf Spot. With regard to the Leaf Blister Mite, *Eriophyses gossypii*, it has been shown that plants immune to its attacks can be bred out in the third generation of crosses between immune and susceptible varieties. Even boll shedding is to a certain extent a hereditary character.

Earliness is certainly a hereditary character in cotton strains. It is in a measure dependent on whether the first developed branches are of a vegetative or fruiting type.

CHAPTER XV

THE DISEASES OF THE COTTON PLANT

The science of disease incidence. Physiological diseases: Mosaic disease or Yellow Leaf Blight—Red Leaf Blight—Rust, Yellow Leaf Blight or Potash Hunger—Leaf curl diseases—Boll shedding—Malformed plants—Loggerhead—Stenosis. Nematode (eelworm) diseases: Root galls—Crown Gall. Bacterial diseases: Angular Leaf Spot—Black Arm—Black Spot—Bacterial Boll disease—Black Boll—Boll Rot—Bacterial infection of cotton bolls. Fungoid diseases: Texas Root Rot—Anthracnose—Wilt or Black Root—Sore Shin, Damping-off, or Seedling Rot—Southern Blight—Internal Boll disease—Leaf Rust—Phoma disease—Leaf Mildew—Arcolate Mildew—Leaf Spot or Leaf Blight—Various maladies.

The Science of Disease Incidence.—The serious study of fungoid and bacterial diseases, as well as those of a physiological nature, that affect cotton and other crops, is of comparatively recent date; and systematic attempts to ascertain the cause and combat those affecting cotton may be said to have commenced from the advent of the present century.

The intelligent application of measures having for their object the prevention and combat of plant diseases involves an understanding of the symptoms, causes, and life-history of these diseases. In the diagnosis of plant diseases it is important to discriminate between symptoms due to the action of living organisms and those due to environment. Foliage discoloration, for example, may be caused by living organisms or, say, excessive moisture at the root of the plant, or partly to both of these causes. The therapeutic measures to apply in the one case would obviously differ from those suitable in the other. It is, however, of primary importance to keep constantly in mind that the effects of the attacks of living organisms are largely influenced by the inanimate environment, as well as by the hygienic condition of the host plant. Plants growing under hygienic conditions, as

regards soil and climate, are better adapted to resist disease than those growing in, say, sour or water-logged soil, or in unfavourable climatic conditions. The farmer is adopting the best preventive measure against disease, by maintaining his plants in a good state of health, by a careful observance of their requirements as regards soil, light, and air.

Plants growing in a wild state are rarely attacked by a serious epidemic of disease, mainly owing to the circumstance that a specific disease almost invariably confines its attacks to nearly allied species of plants. In nature, unrelated plants grow intermingled, and a single species rarely occupies a large area of land. A diseased plant is thus more or less isolated, and the dissemination of the disease to plants of a similar species is repressed, for the unrelated plants in the immediate vicinity are more or less immune to the disease.

The balance of nature is upset when large areas of land are cultivated by a single species of plant such as cotton ; the conditions are then conducive to the diffusion of the numerous maladies to which it is subject, and an endemic disease develops into an epidemic. Again, in nature there is a perpetual struggle for existence, and the plants less adapted to thrive in a particular situation are suppressed by those better adapted, which results in a survival of the fittest. It is well recognised that plants, such as cotton, the character of which has been altered, or "improved" from the farmer's point of view, by selection over long periods, cultivation, and introduction to new countries, are more subject to disease than wild plants of the same species. The persistence of cotton in a wild state is therefore a useful indication of the suitability of a particular region for its cultivation on a commercial scale.

The cotton farmer must therefore adopt every possible means in his power to avoid the introduction of disease into his farm, and should it appear, take immediate and suitable measures to suppress it whenever this is feasible.

PHYSIOLOGICAL DISEASES

The various diseases of cotton that are due to physiological causes affect the plant in different ways ; the whole

plant or only a portion of it may be stunted, certain organisms may assume a malformed or discoloured condition, or the bolls may be shed.

Mosaic Disease or Yellow Leaf Blight.—This disease causes the leaves to become discoloured and to fall prematurely. It was first investigated in the United States some thirty-five years ago. It is generally associated with unfavourable soil conditions, it being too heavy or too light, or is lacking in humus or some essential constituent of plant food.

In the initial stages of the disease, the leaves assume a peculiar yellowing, which causes them to present a checkered or mosaic aspect. The yellowing is caused by deficient nutrition and is at first noticeable in the areas of the leaf most remote from the sources of nutriment supply. Later on, the yellowing may be obscured by the appearance of discoloured spots, produced by fungus organisms in the tissues. Minute brownish spots then appear in the yellow areas, which increase in size centrifugally, and are marked by concentric rings. *Macrosporium nigricantium*, Atk., is generally the first fungus to make its appearance after the mosaic stage. When the leaf is badly diseased, this fungus is often followed by another, *Alternaria tenuis*, Nees. The leaf then assumes a blackened appearance, owing to the black hyphæ and spores of the two fungi, and plants in this condition are stated to be attacked by Black Rust disease. In later stages of the disease, other fungi add their quota to the malady, such as *Cercospora gossypii*, Cooke, *Spharella gossypii*, Atk., and *Colletotrichum gossypii*, Southworth.

Experiments conducted in the United States have shown that where kainit is used as a fertiliser, there is a considerable reduction in the disease, but the results are attributed rather to its physical effects on the soil than as a fertiliser. In the West Indies the disease is prevalent where potash is lacking in the soil, and it is likewise commonly met with in West Africa.

Red Leaf Blight.—This malady is frequently found in cotton-fields where the soil is "worn out" or poor, and especially where potash and nitrogen are lacking, and to a less extent if there is a deficiency of phosphoric acid. Cotton plants affected by this disease make little progress, the leaves turn red prematurely, growth ceases, early maturity

occurs, and little cotton is produced. The remedy is obviously proper fertilising of the soil and careful cultivation.

The attacks of a species of mite, *Tetranychus telarius* ?, sometimes causes cotton leaves to redden in a similar manner.

Rust, Yellow Leaf Blight or Potash Hunger.—This disease is of purely physiological origin, and must not be confused with that caused by the fungus *Uredo gossypii*, syn. *Kuehneola gossypii*, (Lager) Atk. The leaves of affected plants turn red and drop prematurely, and the lint produced is poor and weak. Here again the obvious remedy is fertiliser application, more especially potash, and good cultivation.

Leaf Curl Diseases.—In the West Indies, a disease of a purely physiological nature may attack the plants at any period of their growth, but the plants may return to their normal condition. To term it a disease is rather misleading, for the condition is more of an “abnormality” than a strictly morbid condition.

The internodes of stems and branches elongate, the leaves become strongly crimped at the margin, thin in substance and pale green or almost yellow in colour. There is also a diffusion of yellow along the lines of the larger veins of the leaves. Flowering is restricted, flower buds dry up, turn black, and fall off; other flowers fail to open, but in the latter case the anthers are already brown and withered. This disease is definitely associated with rainy weather, and especially in sheltered or shady situations, and a return of sunny weather proves beneficial.

A disease similar in character to that just previously mentioned is prevalent in West Africa. Affected plants exhibit a peculiar puckering of the small veins of the leaves, which may commence anywhere on the leaf, both when the leaf is scarcely out of the bud or subsequently, which results in the leaves being reduced in size and distorted. Frequently, the colour of affected leaves is inclined to be yellow or mottled, but this chloritic character is not general. Flowering is restricted, but death is not caused. The young branches and upper parts of the plant are often distorted as well. The whole plant may be affected or only a single branch.

The intumescences always occur on the under surface of the leaves, where the stomata are most numerous, and are largely due to local access of spongy parenchyma; palisade

parenchyma also appears to be modified in some cases and the epidermis remains intact. In certain cases there is a splitting of the epidermis of the petioles and young branches. No cause can be ascribed to the disease, which is of a purely physiological character.

Tobacco, groundnuts, and okros (*Hibiscus esculentus*) are similarly affected, and the native Yorubas have given affected tobacco plants a name indicative of sterility, which suggests that the disease is long known.

In the case of cotton plants, not only is flower and fruit production diminished, but in certain cases plants are sterile. Apparently the roots of the plants are not affected and, so far as can be ascertained, fungi and insects are not contributory agents. Soil conditions do not appear to be directly responsible, and fertiliser application had no effect on the disease. Plants that were grown experimentally on different types of soil were equally badly affected in each case. Seeds collected from healthy plants were found on germination to produce more than 50 per cent diseased plants; on the other hand, healthy plants were raised from seeds collected from diseased plants.

Recovery from the disease has not been observed. At the Experiment Station, Ibadan, in the case of native cottons, the general average of susceptibility has been found to be as high as 30 per cent, but Upland cotton, and hybrids of Upland and native cotton, are apparently immune. The disease does not appear to affect cotton grown in the rain-forest belt or near the sea, where more humid conditions are found than farther inland. Seeds collected from diseased plants, and planted in these two regions, produced plants that were not affected by the disease. It would thus appear that the disease is induced by unfavourable climatic conditions, and that the selection of immune varieties is a solution of the difficulty.

Prior to 1914 a similar disease was reported by Germans in East Africa.

Boll Shedding.—The shedding of buds and bolls from physiological causes is a common occurrence. It is frequently due to sudden climatic changes, such as from wet to dry weather or the reverse. It is also liable to occur whenever the amount of water taken in by the roots falls short of that transpired by the leaves, through caking of the surface soil,

undue exposure to wind, drought, root injury by cultivation, excessive growth induced by rain during the flowering and bolling period, and asphyxiation of the roots in water-logged soil. In any case it should be remembered that the cotton plant produces far more squares than it can bring to maturity as bolls ; the surplus is shed throughout the season, and even under normal conditions about 60 per cent of the fruit is shed. The best method of combating this evil is the selection of varieties best adapted to the local soil and climatic conditions, and having due regard for the plant's nutriment and cultural requirements.

Malformed Plants.—In India, an affection, which is generally distributed, results in malformed plants or parts of plants, which produce no flowers or bolls, or produce a very few bolls only, which give light-weight seed of low ginning percentage. No parasite has been observed in association with the malady.

The affection is generally first apparent when the plants are two or three months old. Affected plants produce smaller and more clearly cut leaves, that do not possess the usual sinuses, and hence appear to be crowded together on the stem and branches. They are dark green at first, but gradually change to a reddish or pinkish-yellow colour. The affected plants or branches usually die without producing any cotton. American and Egyptian cottons do not appear to be affected.

There is no indication that the malformation is hereditary ; where seed selection was practised for a period of fifteen years, and seed of affected plants was rejected each year, there was a very slight reduction in the proportion of attacked plants. Ratooned cotton, however, gave a considerably greater proportion of malformation.

In China, Dr. O. F. Cook, of the United States Department of Agriculture, found malformed cotton plants, which he described as Club Leaf or Cyrtosis, that is said to constitute one of the limiting factors to cotton production in the central Yangtze Valley. In this case, the affected plants are dwarfed, distorted, and discoloured, with an angular mottling of the leaves. Other symptoms are anomalous branching and a correspondingly reduced crop. There is no indication of diseased spots or other localised injuries of the kind usually caused by fungi, bacteria, or insect parasites.

The disorder shows analogy and resemblance to the leaf

curl that is caused in some countries by plant lice. In severe cases of attack, all the floral buds are aborted and no fruit is produced. Hot weather appears to favour the early development of the malady. It is considered possible to breed resistant varieties, and to adopt early planting as a palliative.

Loggerhead.—The physiological malady which is distinguished by the term Loggerhead in the West Indies causes the shortening of the stems and branches, and results in a dense, low bush. When the affection begins after normal growth has taken place, the tops of the branches display the bunched character. The general colour of affected leaves is a darker green than normally, and they are strongly mottled with light green and yellow. There may be a puckering along the main leaf veins. The flower buds develop abnormally, and very young flower buds may turn black and drop off the plant. The affection is sporadic in distribution; it may appear and then the plant regain its normal growth, or it may appear when the plant is half grown. It seems to have no connection with any strain of seed or with any impurity in a strain. All that can be suggested is that it is connected in some way with the disorganisation of enzyme activity.

Stenosis.—The name Stenosis or Smalling is the name given by Cook to a newly discovered disease of cotton in Haiti. It is similar in character to the Chinese Club Leaf or Cyrtosis disease, but its effects are more serious, for it causes both abnormal growth and sterility. It not only attacks Upland and Sea Island cotton, but crosses of these cottons with native Haitian cotton (*G. purpurascens*) as well. The Haitian cotton is apparently immune.

Affected plants are usually deficient in chlorophyll, and exhibit different shades of colour with angular spots or areas. Plants may grow normally until even the fruiting stage is reached, when there is an abrupt change into an abnormal habit of growth; branching is irregular, the leaves become contracted and distorted, and most of the floral buds are aborted.

NEMATODE (EELWORM) DISEASES

Root Galls.—Abnormal growth of the roots of the cotton plant is sometimes caused by nematode worms, which live in the tissues and cause malformations. *Heterodera radiculicola*,

Muell., is usually the culprit. The females are a dull white or yellowish colour, with oval bodies, from 0.25 mm. to 0.5 mm. in diameter, while the mature males are cylindrical, and measure from 1 mm. to 1.5 mm. in length. The worms may be distinguished from the tissue of the plant with the naked eye. They multiply with great rapidity, for each female is capable of producing from 100 to 200 eggs, and the life-cycle of the worm is completed in about one month.

The injuries caused by the presence of the worms devitalise the tissues, and then putrefactive organisms produce extensive diseased areas. The complete destruction of all diseased plants is advisable, and care should be observed in moving them from one place to another. Susceptible weeds should be eradicated, and crop rotation should be practised with immune crops such as cereals, certain varieties of cowpeas and groundnuts.

Crown Gall.—At present this disease appears to be of no great economic importance. It causes galls to form on the stem, about the level of the ground, and on the main roots. *Pseudomanus tumefaciens*, S. & T. Star., is responsible for this affection.

BACTERIAL DISEASES

Angular Leaf Spot.—This disease is caused by *Bacterium malvacearum*, Smith, and it is widespread in the United States, West Indies, West Africa, and other cotton-growing countries. It is named from the angular spots that appear in the leaf. The appearance of the disease is first indicated by the formation of small spots in the leaf, which are bounded by the veinlets of the leaf; in certain cases these spots have also been observed on the bracts, stem, and bolls. In course of time the spots may become confluent. Later they turn a blackish colour and then brown, and are often gally in appearance. Eventually the destroyed tissues fall away leaving perforations with jagged edges, and the fall of the leaf is expedited.

Investigations conducted at the South Carolina Experiment Station resulted in the discovery that the disease is seed-borne, and is not carried in the soil. Further, that its absolute control may be secured by delinting the seed with sulphuric acid, and treating it with mercuric chloride. This treatment is found to hasten germination and to afford

protection from the Anthracnose disease. In the West Indies the disease has been checked by spraying with Burgundy mixture, but it was ineffectual in regard to diseased bolls.

In Korea this disease attacks seedlings, stems, bolls, and leaves, and its prevalence is favoured by wet climate and lack of potash in the soil.

Black Arm.—In Sudan the Black Arm disease is one of the most serious problems with which the cotton grower has to contend, and it is likewise troublesome in the West Indies and Nigeria. It is caused by *Bacterium malvacearum*. The disease attacks the young parts of the stem and branches, and causes the cortex to turn black on the surface, and to dry up and die. It also causes lesions in the stem, which are often invaded by the larvæ known as Red Maggots, and it frequently girdles the smaller laterals. The destruction of affected parts should be practised as a preventive measure.

Black Spot.—*Bacterium malvacearum* is likewise responsible for this disease in the West Indies. In the case of young bolls, it first appears as a small black spot near the junction of the stalk and the boll inside the calyx. This spreads, and all tissue on one side hardens and then dies. The boll bends over towards the diseased side and development is checked; all lint on this side of the boll is either destroyed or discoloured, and the boll frequently falls before it opens. Bolls attacked at a later stage exhibit dark green areas, which spread and become black and depressed in the centre; in severe cases of attack, the lint is affected and turned green and the boll drops. In any case the boll's development is arrested, and the quality of the lint is depreciated.

Bacterial Boll Disease.—*Bacterium malvacearum* causes yet another boll disease in the West Indies. It first appears as a water-soaked spot or spots on green bolls, which may spread over the whole boll. The diseased portion turns brown and then reddish-black. Diseased carpels usually dry up and become prematurely hard, separate at the tips, and open at the side according to the part affected. The exposed lint becomes stained and matted. In wet weather, the watery spots present an easy means of access for boll-rotting fungi, such as Anthracnose.

Black Boll.—The Black Boll or Internal Boll Rot disease in the West Indies is also considered to be caused by bacteria.

The rot begins inside the boll and spreads, turning the lint dark brown and then black. The seeds inside the attacked boll swell, and such bolls are more resistant to pressure than normal bolls. Otherwise, the only external symptom of the disease is the peculiar shape of the affected bolls; they are nearly spherical and tapering to a sharp point, instead of being oval. Affected bolls drop, or dry up and open slightly, when an almost complete absence of lint is apparent. The destruction of diseased bolls is recommended as a control measure.

Boll Rot.—This disease is commonly met with in the United States and the West Indies, and is caused by *Bacillus gossypinus*, Stedman. It starts in the inner tissues of the boll, near the point of attachment of the stalk, and spreads; the lint and seeds are transformed into a slimy mass, and the infection may eventually reach the outside of the boll. Young bolls that are attacked are completely destroyed, but in the case of older bolls, a part of the contents may mature and they may open. In this case also, the diseased bolls should be destroyed as a control measure.

Bacterial Infection of Cotton Bolls.—In India, the shedding of bolls of Cambodia cotton has been found to be accompanied by a discoloration of the bolls, seeds, and lint, which exhibit a slimy and rotten appearance. This rotting and premature falling of young cotton bolls is attributed to a bacterial organism, but not to *B. malvacearum*. No fungus has been observed to be associated with the disease in its early stages, but insect attacks afford a ready means for its entrance.

FUNGOID DISEASES

Texas Root Rot.—Some cotton growers in Texas consider this disease to be even more serious than the boll weevil. It is caused by the fungus *Hydnum omnivorum*, *sp. nov.*, syn. *Ozonium omnivorum*, Sh., *Phymatotrichum omnivorum*, (Sh.) Duggar. It also attacks many trees, plants, crops, and weeds.

The character of the disease is a sudden wilting of the plant, which dies within a day or two. The roots become covered with a whitish mould, which later changes to yellow-brown. The tap root is usually attacked first and near the surface of the ground; it is generally killed outright, and the

plant is supported by abnormally developed laterals. The fungus derives its nourishment from the living tissues of the root, and it also causes certain fermentations to be set up, which kill the affected portions. When the roots of a plant become seriously injured, the amount of food material that is absorbed by the plant from the soil becomes inadequate to support the transpiration from the leaf surface, and the plant wilts and eventually dies.

The fungus spreads through the soil from plant to plant in a centrifugal manner. Statements to the effect that the disease can be transmitted by means of the seed have been proved incorrect. The disease is perpetuated through the winter in fleshy roots, such as sweet potatoes and carrots, and on cotton plants left in the ground. There are no indications that it is carried over in the soil.

The fungus appears to grow best where soil aeration is poorest. Warm weather following rain is especially favourable. The control measures suggested are: the eradication of all susceptible host plants, deep ploughing in the autumn, and a three-year crop rotation with immune crops such as cereals. Fallowing is likewise a valuable deterrent. It has been found that soaking the soil with formaldehyde stops the spread of the disease; the cotton plants in soil so treated shed their leaves, but afterwards recover and resume growth.

Anthracnose.—This disease is caused by the fungus *Colletotrichum gossypii*, Southworth, and is prevalent in the United States, West Africa, West Indies, and to a less extent in several other countries as well. It attacks the bolls, stem, and also young seedlings. On bolls, the disease is first evident by the appearance of small red or brown areas, of which the central portions are depressed. These later become black in the centre, and fungus spores, in the form of small greyish pustules, appear on the black portion; the pustules change to a pink colour, so that the central portion of the black area is covered with a pink mass of spores. The boll's development is arrested and it does not open properly, while the lint is rendered discoloured and useless through fungal hyphæ.

Bolls attacked in a later stage of their development may

not be seriously injured, but when very young bolls are attacked they dry up and fall off the plant.

The hyphæ of the fungus may penetrate the seed in diseased bolls, and lie dormant until the seed begins to germinate, when it becomes active and destroys the young seedling, causing it to, what is known as, "damp off".

The attacks on the stem of the plant are not usually of a serious character.

Seedlings are also frequently infected with the disease through spores of the fungus that have settled on the lint of the seed. Such spores may be destroyed by immersing the seed, previous to planting, in a 1 : 1000 corrosive sublimate solution (*i.e.* 1 oz. of corrosive sublimate to 7 gallons of water) for from ten to fifteen minutes, and then spreading the seed to dry before planting. But this method is of course quite ineffectual against hyphæ-infected seed, which should be discarded for planting purposes. In this connection it is to be observed that fungus spores on the lint and fuzz attached to cotton seed may be effectively destroyed if the seed is delinted by immersing it in concentrated sulphuric acid, then draining the seed and washing it in a large volume of running water. It is considered that the immersion in the acid up to a period of four hours has no effect on germination; further, that seeds treated in this manner grow more quickly and the resultant plants are more vigorous and healthy.

Investigations conducted at the South Carolina Experiment Station indicate that the disease may be controlled by a preliminary drying of the seed and storing it for one year. Formerly it caused an annual loss of from two to five million dollars to cotton growers in South Carolina, but it is now brought under control with comparatively negligible losses. Other American authorities recommend the use of three-year-old seed as a means of controlling the disease.

The collection, and destruction by fire, of all diseased plants, as well as the selection of seed for planting from uninfected plants, should be practised as a control measure.

Wilt or Black Root.—Wilt disease of cotton is commonly met with in the United States and also in India. In the former country it is attributed to the fungus *Fusarium*

vasinfectum, Atk., but the Indian wilt is considered to be due to a markedly different species of *Fusarium*.

In the United States the disease is reported to be most prevalent in sandy soil and in wet seasons, and in such situations the disease is sometimes responsible for a reduction of the yield of cotton by as much as 80 per cent.

The characters of the disease are: the leaves wilt and fall without apparent cause, but on examination the stem and root are found to be discoloured brown or black. Sometimes the main stem of the plant is dwarfed as a result of disease attack.

In the Central Provinces of India, damage due to the disease is variously estimated at from 5 to 47 per cent of the crop. Native cottons are more susceptible to the disease than exotic varieties, although some native varieties are much less susceptible than others.

Recent researches indicate that wilted plants contain a higher proportion of aluminium than healthy plants, and point to the toxic effect of aluminium as the primary cause of the disease, fungi being probably secondary agents.

The fungus is able to persist as a saprophyte on decaying vegetable matter in the soil for several years. It is therefore recognised, both in America and in India, that it is impracticable to devise remedial or preventive measures, and that the only hope of combating the disease is by raising immune or resistant varieties, and considerable success in this direction has already been attained in both countries.

Sore Shin, Damping-off, or Seedling Rot.—This variously named disease is caused by *Rhizoctonia solani*, Burt = syn. *Corticium vagum*, P. It is considered to be the most serious fungus disease of cotton in Egypt, though in the United States it is of minor importance. According to Balls, it is ubiquitous in Egypt, and its sterile mycelium must be regarded as a gigantic network stretching throughout the soils of the country.

The disease attacks seedlings, causing cankerous spots to form on the stem and roots; growth then ceases, the leaves turn yellow, and the plant may die. Except in the case of wounds, the cotton plant is immune as soon as the corky layer is formed.

The growth of the fungus is said to be arrested when the

temperature rises above 33° C., so where it is prevalent it is advisable, when it is feasible, to defer planting until this takes place. The fungus, however, passes long periods in the resting stage, when small dark knots of twisted mycelium are formed.

Southern Blight.—*Sclerotium Rolfsii*, Sacc., is the causative fungus of this disease, and it has many host plants in the United States of America. Affected plants lose their green colour, wilt and die. The fungus may be found around the base of the stem and on the roots, and may be recognised by a dense mass of mycelium, covered by many of the characteristic small, brown, spherical bodies known as sclerotia.

Sclerotia bataticola, an allied but obscure fungus, attacks cotton in India, Egypt, and Nigeria, but in America it attacks sweet potatoes and has not been reported on cotton.

Internal Boll Disease.—This disease is new to science. It was discovered in the West Indies, and is due to a highly specialised form of fungus that is conveyed to cotton plants and is inoculated into the boll through the medium of plant-sucking bugs, and principally by *Dysdercus* spp.

Leaf Rust.—This disease is prevalent in the West Indies and Nigeria, and is caused by the fungus *Uredo gossypii*. It produces small brown pustules on the leaves, which are at first covered by the epidermis, that later bursts and discloses tufts of yellowish-brown spores, usually on the under surface of the leaves. On the upper surface these are shown as small purplish-brown spots. It is most abundant on old plants, and on plants in a poor state of health due to unfavourable conditions of growth.

Phoma Disease.—This disease was recently recorded in Arkansas, and made great progress during a period of cool, wet weather; in small areas, plants were killed outright. It attacks all parts of the plant above ground, and rapidly advances through the tissues. A change to more favourable weather conditions abruptly checked the progress of the disease and many plants recovered.

Leaf Mildew.—In the West Indies and Bombay, leaves of cotton plants are attacked by a mildew caused by *Ovulariopsis gossypii*, Wakef. The upper surface of diseased leaves

becomes blotched with purple having a yellow margin, in irregular areas ; the under surface being covered with a white web of superficial mycelium, which has a powdery appearance due to the spores produced. The disease chiefly appears on old leaves that have passed their prime, and hastens their fall. It strongly resembles the well-known powdery mildews of the grape vine, rose, and wheat.

Areolate Mildew.—In the United States, Nigeria, and the West Indies the leaves of the cotton plant are affected by another mildew, distinguished as *Areolate*, which is caused by the fungus *Ramularia areola*, Atk. Small affected areas on the leaves have a mildewed or frosted appearance, and are yellow tinted when looked at from above. These areas are more transparent than the rest of the leaf. The hyphæ are generally most abundant on the under surface of the leaf. The disease is not very common, and it is not likely to become of any serious importance.

Leaf Spot or Leaf Blight.—Although this is a common disease of the cotton plant in the United States and the West Indies, it rarely becomes serious. It is caused by the fungus *Sphærella gossypii*, Atk., and forms circular, sharply defined spots on the leaves, which are colourless or light in the centre, bounded by a dark red-brown or black line. It also causes blotches on the bolls. Its attacks are for the most part confined to the older leaves, or those of plants that are debilitated by physiological causes.

Various Maladies.—At the Experiment Station, Ibadan, Nigeria, native and Brazilian cotton plants exhibit a blackening of the midrib and veins of the leaves. Frequently the leading shoot is affected, and is killed as a consequence. A yellowish, waxy substance appears to be formed, which covers the surface of the affected parts. The origin of the disease is not clear. In the waxy substance bacteria were found in abundance, as well as a *Fusarium* fungus. The latter takes the form of an effused pink mould. A *Colletotrichum* fungus was likewise bred out in the laboratory from affected tissues. Occasionally the lower portion of the stem is attacked with similar symptoms and a kind of canker is formed.

In Nigeria a boll rot is caused by a *Diplodia* (*Thyridaria tarda*) fungus identical with that which attacks cocoa pods.

In the West Indies a *Phytophthora* is reported to cause

the Soft Rot disease of cotton bolls. It spreads after heavy or prolonged rain, and infection is presumed to be brought about by the splashing of the motile zoospores from the soil on to the lower bolls. The control of the disease by spraying with Bordeaux mixture is suggested.

CHAPTER XVI

INSECT PESTS OF COTTON

Insect ravages, causes and effects. The Mexican cotton boll weevil—Description and life-history of the boll weevil—Nature's control of the weevil—Methods of weevil control—Weevil control by poisoning—Apparatus in use for poison application—Character of poison important—Time of applying poison—Beneficial effects in regard to other pests—Indirect methods of weevil control—Cultural methods conducive to frustrate weevil attack—Precautionary methods necessary—The Arizona wild cotton weevil—Possible introduction of the boll weevil to other countries. The pink boll worm—Description and life-history—Crop injury attributed to the pink boll worm—Natural enemies of the pest—Methods of controlling the pink boll worm—Control measures in Egypt. The American boll worm—Description and life-history—Methods of control. *Earias* boll worms: The spiny boll worm—Description and life-history—Damage done by the spiny boll worm—Nature's method of control—Mechanical methods of control—Damage in India by *E. fabia*. The Sudan or red boll worm—Description and life-history. Various boll worms. Stainers: The genus *Dysdercus*—*D. cingulatus* in India—*Dysdercus* spp. in West Africa—Life-history of *D. supersticiosus*—Transmission of disease by stainers. Dusky bugs: Life-history of *Oxycarenus hyalinipennis*—Damage by dusky bugs—*O. latus* in India—Various plant bugs. Leaf-eating insects: Egyptian cotton worm—Wide distribution—Description and life-history—Controlling factors—*Prodenia ornithogalli* in the West Indies—The American cotton worm—Life-history—Natural checks—The lesser cotton worm—The cotton leaf roller—Semi-looper caterpillar—The bronze beetle—Leaf hoppers—Cutworms. Flower bud maggot—Stem borers—Root pests—Red maggot—Mites. Aphis or green fly: Life-history. Thrips—Scale.

Insect Ravages, Causes and Effects.—As is the case with diseases, man is largely responsible for the ravages caused by insect pests of cotton and other cultivated crops. He destroys large areas of forest, scrub, or virgin growth, where plants, animals, and insects thrive in a state of equilibrium, and substitutes a crop of one species of plant, which provides an unlimited food supply for any particular insect which has a taste for that crop, after having already destroyed or driven away its natural enemies and competitors. The difficulty

is of course greatly enhanced where no forest intervenes as a deterrent.

This condition of affairs is most unfortunate in the case of cotton, which is a member of the *Malvaceæ*, a large family of plants the members of which are widely distributed both in a wild and in a cultivated state. Many insects, which originally fed on other species of the family, seem readily to adapt themselves to cotton, so that wherever cotton is introduced it finds pests awaiting it on some other Malvaceous plant. Moreover, it is peculiarly attractive to certain insects, because of the sweet exudation of the glandular structures present on many of the plant's organs; while the cotton bolls, with their soft, pulpy interior and developing seeds, form an attractive breeding-ground for particular insects.

It thus follows that cotton suffers more from insect attacks than most staple crops, and it is probable that more insects attack cotton than any other cultivated plant; more than 500 species of insects have been recorded as inimical to it, and some of these are the most destructive pests in agricultural history. The estimated damage to the United States cotton crop, attributed to insects, increased from 7.9 per cent of the value of the crop in 1909 to 26.6 per cent in 1923.

The plant is attacked at every stage of its existence, and practically every part of the plant is attacked by some insect pest or other. Their ravages begin at the seedling stage and continue after the crop is harvested. Grasshoppers, cutworms or caterpillars, and various beetles attack the young seedlings. Sucking bugs, fly maggots, and lepidopterous boring larvæ later attack the leaf buds, flower buds or squares, and the growing point of the stem. Still more bugs and lepidopterous larvæ, mites, beetle larvæ, aphides, thrips, and fly grubs attack the developed leaves. Flowers that have escaped the bud-ravaging insects are attacked by flower beetles, while wireworms, millipedes, and other beetle larvæ attack the root. As soon as the bolls appear they are ravaged by boll weevils, boll worms, and stainers, although many of these find food in the young tender parts of the plant before this period. In addition to the damage caused by the direct attack by insects, many of them convey bacterial and fungoid diseases of the plant.

As regards the control of a particular insect pest, the best results are almost invariably obtained by studying the minutest detail of its life-history, particularly with respect to its natural enemies and food plants, with the view to discover some weak point in the annual cycle, in which a change may be introduced and the cycle disturbed, such as the destruction of alternative food plants when cotton is absent. Control methods of this nature are invariably more effective and, what is generally of vital importance to the farmer, more economical than mechanical or chemical processes. The latter frequently involve a large expenditure for material, apparatus, and labour, thus making the risk of expense greater than is justified by the benefits that accrue.

THE MEXICAN COTTON BOLL WEEVIL

The most important of the insect depredators of cotton is the Mexican boll weevil beetle, *Anthonomus grandis*, Boh. Some idea of this pest's depredations will be appreciated when it is stated that the estimated average annual damage done by it to the cotton crop is estimated at 6 million bales, which, at 1s. per lb. of lint, amounts to £150 million. To this sum must be added the losses sustained through land depreciation, the closing of cotton ginneries and oil mills, and other indirect losses resulting from the boll weevil's infestation. The larvæ of the beetle live inside the flower buds and bolls and feed upon the interior substance. The infested squares usually fall to the ground, but the infested bolls mostly remain on the plants and become stunted, or dry or decay. Before the squares are formed the young leaf buds are eaten as food by the weevil.

The plateau region of Mexico or Central America is the original home of the boll weevil. It is reported to have caused cotton cultivation to be abandoned in the vicinity of Monclova, Mexico, as long ago as 1862. It is also known to occur southward to Guatemala and Costa Rica, and in the eastern portion of Cuba. It spread through the greater part of Mexico, and about 1892 it crossed the Rio Grande into the United States near Brownsville, Texas. It is not known whether the weevil flew across the border or whether it was

introduced with seed cotton that had been brought to Brownsville to be ginned.

Within two years it had become disseminated throughout six counties in southern Texas; since that date it has extended its field of depredation in the United States at the rate of from 40 to 160 miles per annum. For the first ten years after its arrival it spread at an average annual rate of 5640 square miles. From 1901 to 1911 it increased its annual range to 26,880 square miles, and in 1916 it reached 71,800 square miles. At the end of 1922 over 614,213 square miles of United States territory had been invaded by the boll weevil, so that only 91,000 square miles remained uninfested. Quite 87 per cent of the cotton belt is now infested by this pest, and the infested area produces 95.9 per cent of the cotton crop of the cotton belt. The extreme western and northern sections of the main cotton belt are the only cotton-growing areas that remain uninfested at the present time. In certain newly infested regions its ravages have caused the panic-stricken cotton farmers to lose as much as 50 per cent of their crops.

Description and Life-history of the Boll Weevil.—The boll weevil belongs to the order of insects designated by entomologists as *Coleoptera* and to the family *Curculionidæ*. The adult weevil is about one-fourth of an inch long, and about one-third of its length in breadth; included in the length measurement is that of the snout, which is about half the length of the body. The insect may be slightly larger or smaller than these dimensions according to the quantity of food that it has obtained in the larval stage.

In colour it is light yellow when it emerges from the pupal stage, but in a few weeks' time it changes to grey or nearly black. It hibernates in the adult or beetle stage under old cotton plants, trash, or in woods.

The female deposits her eggs during the spring and throughout the cotton-growing season in cavities, which it makes by eating into the flower buds and bolls. Grubs hatch out of the eggs in about three days, and at once commence to feed on the interior substance. The grub or larva passes into the pupa stage in from seven to twelve days; at this period it is about $\frac{3}{8}$ ths of an inch in length.

The adult weevil issues from the pupa in from three to

five days, and about five days later commences to produce another generation. It has been estimated that the possible progeny by a pair of weevils in a single season is $12\frac{3}{4}$ millions; happily nature has its own methods for checking such inordinate procreation. From two to three weeks usually elapse between oviposition and the development of the mature weevil. About equal numbers of each sex are produced. Adults seek protection for most of the time under the bracts of the squares.

Generally, females refrain from ovipositing in the buds or bolls that have already been visited by other females, but late in the season several eggs may be laid in one bud or boll, and as many as fifteen larvæ have been found in one boll. The buds are preferred to the bolls, and the latter are not seriously damaged so long as a good supply of buds is available. The insects do not injure the mature bolls. The males also feed upon the buds and bolls and do not move until the food becomes impaired. The cotton plant and the Arizona wild cotton, *Thurberia thespesioides*, are apparently the only plants on which the weevils breed.

The presence of the weevil is early rendered conspicuous in the cotton fields by the falling of the infested squares, and the "flared" bracts of the infested squares on the plants. If the buds of such squares be cut open a white curved grub is observed feeding upon the contents.

Investigations conducted in Louisiana have shown that the weevil is principally active between 9 A.M. and 5 P.M., when 65 per cent of the eggs are laid; 11 and 6 per cent of the eggs are laid in the early morning and in the night respectively. Weevils live for about fifty days in the summer, but during the cooler seasons they may live for six months, and one has been known to exist for eleven months. When the cotton plants are destroyed by frost, most of the immature weevils are destroyed with them, but so long as a supply of food is available the immature insects continue to develop and eventually reach the adult stage.

At the approach of cold weather the mature weevils seek protection for the winter in the woods, in Spanish moss growing on trees, haystacks, farm buildings and hedges, and under trash and in crevices in the ground in the cotton and maize fields. During hibernation the weevils eat no food and

are virtually dormant, although they move about to a certain degree on very warm days. The proportion of weevils that survive the winter varies with the severity of the weather and the amount of protection afforded by their hiding-places. That the fields do not provide the most successful hibernation conditions is amply demonstrated by the damage done early in the season to cotton which is adjacent to woods and similarly sheltered hibernating places. Experiments conducted with the view to ascertain the number of weevils that normally survive the winter in Louisiana and Texas, show that the average survival is 6 per cent.

Climatic conditions govern the date of emergence from hibernation, but it usually commences early in March in the southern portion of the cotton belt, and a little later in the north ; it has been known to last until the end of June.

Although the weevil's means of locomotion is by flight, it is only a weak flier compared with many other insects, and the direction of its flight is largely determined by the wind. In the absence of wind it is as likely to fly in one direction as another. Its flights are not protracted, but with the aid of a favourable wind and by means of successive short flights it has been known to travel as much as 40 miles in a very short time. With the exception of the movements to and from hibernating places in the autumn and spring respectively, it exhibits little desire to fly at all until what has been described as the dispersion period, which commences about the middle of August and extends until the end of the season. Its migratory instinct for discovering new pastures serves to explain the weevils' rapid diffusion through the cotton belt.

Nature's Control of the Weevil.—Nature's principal agents in controlling the pest are frost, heat, and parasitic and predatory insects. Birds also assist in its suppression. Weevil mortality is very high in infested squares that are exposed to the sun's rays ; inspections have shown that as many as 90 per cent of the immature weevils in cotton fields have succumbed to heat in this manner. As the larva has no means of locomotion, those that are in the squares which fall to the ground are destroyed by the heat in a very short time. That dry seasons are inimical to the weevil has been recognised for many years, as well as the difficulty of controlling the pest in wet seasons. A mild winter followed by

a rainy, cloudy summer provide the ideal climatic conditions for weevil multiplication.

There are forty-five different species of insects which are known to prey on the boll weevil, and twenty-three of these are parasites. The latter lay their eggs in the immature weevil, and the young insects that develop therefrom feed upon the weevils and eventually kill them. The extent of the controlling effect of parasites is by no means constant, for on occasions little weevil mortality can be credited to them, while sometimes as many as 75 per cent of the immature weevils are destroyed by this agency.

Of the insects that prey on the weevils as food, ants are most conspicuous, and at least twelve species of ants can be placed in this category. They attack the immature weevils in the squares; in certain cases from 25 to 50 per cent of the immature weevils in the fields have been destroyed by them.

Methods of Weevil Control.—Numerous methods for controlling the pest have been suggested, but in many cases these have no proper regard for the habits of the insect, while in others the important matter of expense has not been duly considered. Some of the most prominent ineffective methods that have been proposed may therefore be briefly reviewed with advantage.

The feasibility of hand-picking adult weevils in the spring and infested squares later in the season has received a large amount of attention. The efficacy of this procedure is admitted provided it is carried out with sufficient thoroughness; but practically the labour difficulty associated with it has almost invariably proved insurmountable. This method is therefore only feasible of adoption when an abundance of cheap labour is available and weevil infestation is not abundant. Numerous efforts have been made to collect the weevils by a large variety of mechanical devices, but all have in turn been condemned.

Attempts to avoid weevil attack by late planting have signally failed. Numerous experiments have demonstrated beyond all doubt that considerable numbers of weevils are able to survive till after the latest date in the spring when cotton could be profitably planted, even if the weevils were entirely eradicated. Weevils have been known to emerge

from hibernation as late as the end of June, and many of them have survived afterwards without food for from six to twelve weeks.

The early planting of cotton as a trap crop has also proved ineffective. The destruction of the weevil by attempting to attract it to lights has likewise failed, for, although numerous insects may be attracted by lights, the boll weevil is not affected in this manner. Other proposed remedies that have been condemned as ineffectual are poisoning the seed with chemicals, sweetened poison baits, contact poisons designed to destroy the weevils by suffocation, chemicals and fumigants having a repellent character, and topping the cotton plants.

Weevil Control by Poisoning.—After many years of patient work the United States Bureau of Entomology has elaborated a profitable method of combating the pest by poisoning the plants with powdered calcium arsenate. Where weevils are seriously injuring the crop it is maintained that this method may be profitably employed provided the land is sufficiently fertile to produce half a bale (250 lb.) of lint per acre when weevil damage is eliminated. Further, if circumstances permit of poison applications being made at the proper time and in the proper manner; if an adequate supply of dusting machinery and poison is available; and if the costs of the calcium arsenate, labour, and depreciation on dusting machinery do not exceed the current value of 100 lb. of seed cotton per acre.

Apparatus in Use for Poison Application.—Only machinery which has been specially manufactured for the application of the poison for boll weevil control can be economically employed; the use of makeshift devices is futile. Generally a machine consists of a fan or blower, a dust container or hopper, and the feeding mechanism. The hopper should hold as much poison as can be conveniently transported; the feeder should regulate the dust discharge in the quantity desired, and the fan should produce a current of air sufficient to deliver the dust at the required points. There are various types of dusting machinery in use, and of these the smallest are the hand guns. They are operated by one labourer by hand, and are generally unsatisfactory, for they are frailly built and are laborious to operate. They cost from \$12 to

\$25 each. It is possible to deal with up to 8 acres of cotton throughout the season with one hand gun.

The smallest type of traction duster is the one-wheel, one-mule machine, which is handled similarly to a walking cultivator. It is furnished with two spraying nozzles, and will treat two rows of cotton at a time, and cover from 15 to 20 acres of cotton in a night's operation. It costs from \$100 to \$125, and can deal with up to 60 acres of cotton in a season.

The two-wheel, two-mule cart machine, which straddles a row of cotton, is furnished with three nozzles and covers from 25 to 30 acres of cotton in a night's operation. This machine costs from \$250 to \$400, and is able to deal with up to 100 acres of cotton in a season.

The hand guns depreciate 100 per cent and the larger machines 25 per cent in a season.

Various types of lighting equipment have been tested for night operations. Finally a satisfactory light, using a compressed carbide cake as fuel, has developed. Many manufacturers furnish a model of this light as standard equipment with their large dusting machines. The cost of various lights in use varies considerably. Those suitable for the large cart machine cost from \$30 to \$45. The bicycle headlight type costs from \$2 to \$3, while a satisfactory cap light may be purchased for \$1.50.

Experimental flights have demonstrated that aeroplanes can be successfully employed to apply poison to cotton plants to destroy the boll weevil. Recently as many as 700 acres per hour have been dusted by this method. It is reported that, in the southern cotton-growing region, commercial contracts for aeroplane dusting of cotton fields at \$1 per acre are being made for the 1926 season.

Character of Poison Important.—Calcium arsenate should only be applied in the form of dry dust. It should contain not less than 40 per cent of arsenic pentoxide, nor more than 0.75 per cent of water-soluble arsenic pentoxide, and have a density not less than 80 or more than 100 cubic inches per lb. If there be an excessive amount of water-soluble arsenic present in the poison the cotton plant's foliage becomes injured by "burning". The term "burning" is applied to plant injury by soluble arsenic, because it probably best

describes the appearance of the injury. On the other hand, if the total arsenic content is too low, the powder is not sufficiently poisonous to control the weevil.

The density of the material is likewise of importance, for if it is too heavy and runs much less than 80 cubic inches to the lb., the proper type of dust is not produced to cover the cotton plants thoroughly. Should the material be too light and run much over 100 cubic inches to the lb., it becomes blown away too rapidly from the plant, by any light air currents, to be effectual.

Time of applying Poison.—In the course of the weevil control investigations it early transpired that there existed little hope of successfully poisoning weevils if such measures depended solely upon the amount of poison that they would consume in the course of their feeding. It was observed that they drank water very regularly under breeding-cage conditions, and it was correctly assumed that, under field conditions, they would procure this apparently essential moisture by imbibing the rain or dew that collects on the leaves of the cotton plants. It was found that when poisoned plants were kept absolutely dry, only a slight weevil mortality resulted, while as soon as moisture was introduced the mortality increased enormously. It therefore follows that most of the success in poisoning is due to ingestion of poison by the weevil while drinking, which serves to demonstrate the necessity for using a powder fine enough to be readily taken up by the dew and held by it in suspension for the weevils to drink.

Applications of poison should be made only when the plants are moist and the air is calm ; these conditions usually obtain at night, early in the morning, and late in the evening. Completely successful results can only be attained if the fine particles of poison dust thoroughly cover every part of the plant, and it is essential for the plants to be moist for the poison to adhere readily to them.

The contention that the weevils are killed by drinking the poisoned moisture, "poisoned dew", has been recently contradicted by later investigators, who maintain that they are killed by ingesting the poison with their food, and contend therefore that the poison should be more particularly applied to the squares, buds, and bolls rather than to the foliage.

As soon as from 10 to 15 per cent of the squares have been punctured by weevils it is desirable to commence applying the poison, and at the rate of 5 to 7 lb. of calcium arsenate per acre at each application. Experienced operators are able to make 4 lb. per acre suffice. Usually three applications, one every four days, are necessary, or more until the weevils are under control. Should heavy rain occur within twenty-four hours of dusting, more poison is to be applied immediately. Dusting is then suspended until the weevils again become abundant. One or two applications are necessary late in the season if the weevils become numerous enough to injure the young bolls.

This method of attack is not advocated with the idea of exterminating the weevils, but of controlling them sufficiently to permit of the production of a full crop of cotton. The cotton plant always produces a much greater number of squares than it can possibly bring to maturity as bolls, so that even under normal conditions quite 60 per cent of them are shed, and up to a certain point weevil-damaged squares do not materially reduce the cotton crop.

It is important to bear in mind that the poison has no effect on the immature weevils at work in the squares and bolls, and that it only reaches and kills the mature weevils in the fields. Although a single application of the poison will probably destroy vast numbers of adult weevils, their places would be quickly taken by the rapidly developing insects in the squares and bolls unless the applications be repeated at proper intervals of time. It has been found that if the cotton plants be kept thoroughly poisoned for about twelve days, the weevils and their offspring are completely controlled. That greater progress has not been made in combating the pest by means of calcium arsenate is due to the comparatively small proportion of the planted areas that is treated with the poison, so that treated areas are soon reinfected from untreated fields. If the application of the poison were generally adopted there would soon be a noticeable reduction in the number of weevils, and it would quickly be eliminated as a serious factor in keeping down production.

The adoption of this method of poisoning has increased the yield of cotton in certain cases to as much as from 500 to 1000 lb. of seed cotton per acre.

Beneficial Effects in regard to other Pests.—The methods recommended for controlling the boll weevil are practically identical with those suitable for attacking the pink boll worm, another pernicious pest of cotton which is dealt with later on in this work, so that the benefits accruing from weevil control are supplemented by those derived through the pink boll worm control. Similarly the use of calcium arsenate serves also to control the leaf-worm or army-worm, which sometimes causes considerable damage to the cotton crop by defoliating the plants. Hitherto Paris green was generally used for poisoning the leaf-worm, but calcium arsenate is quite as satisfactory for this purpose, and is not only cheaper but is less injurious to the plants.

Indirect Methods of Weevil Control.—In addition to control by poisoning, there are a number of indirect methods of controlling the boll weevil that can be practised with advantage. Of these the destruction of infested cotton plants after the harvest and before the weevils have hibernated is one of the most effective means of reducing weevil infestation. In this connection the most successful results are obtained by totally destroying the plants with fire, or by ploughing them deeply underground before the advent of frost. This procedure, in addition to killing weevils in the squares and bolls, destroys potential hibernation quarters for weevils in the fields.

Much good may be done in the elimination of other hibernation quarters by burning trash in the vicinity of the fields, such as that which accumulates in the fence rows and ditch banks.

The practice of growing ratoon and volunteer cotton is objectionable, as such plants develop rapidly in the early spring and provide food and breeding-places for the weevils much earlier in the season than would otherwise be the case, and planted cotton becomes infested with their progeny at an abnormally early date.

Where it is not feasible to destroy the cotton plants with fire or to plough them into the ground, beneficial results may be obtained by grazing cattle, sheep, or goats in the field. There is unlikely to be sufficient poison on the plants, and especially late in the season, to injure stock.

Cultural Methods conducive to frustrate Weevil Attack.—

The necessity for producing the cotton crop as early as possible in the season is apparent from the preceding remarks relative to the weevil's life-history and habits, for it virtually constitutes a race between the cotton plant and the weevil. There is the additional necessity of expediting the harvest so as to permit of the destruction of the plants as early as possible in the autumn. Indeed the adoption of every practicable measure conducive to the production of cotton before the weevils have increased sufficiently to cause serious damage is to be strongly commended.

The early removal of the old cotton plants, and the autumn or winter preparation of the land to provide a good seed-bed in readiness for early spring planting, are the first steps ameliorative of conditions for early crop production. As regards early planting, it is considered advisable to incur the risk of replanting rather than postpone planting because of the danger of cold weather.

The planting of early-maturing varieties of cotton is also recommended. Since the boll weevil invasion much attention has been devoted to the development and introduction of cotton varieties which mature their crops earlier in the season than those that were previously in favour. Varieties that may be placed in this category, and that have proved successful under the new conditions, are Triumph, Cook's Improved, Rowden, Cleveland Big Boll, Lone Star, Trice, and Columbia.

In the early days of the weevil invasion it was considered that the cultivation of the slow-maturing, long staple Upland varieties would have to be eliminated. But several new varieties of this type have been developed, which are both prolific and early maturing; of these Webber and Express are the best known.

Since the boll weevil invaded the Sea Island cotton-growing districts in the south-east, the annual average production of this valuable cotton has declined from 90,000 bales during the ten years 1908-17 to 2000 bales in 1920; at the present time very little of this type of cotton is grown at all. This variety is peculiarly susceptible to boll weevil damage, owing to the large size of the plants and to the late maturity of the crop. In this case the problem has been

solved to a certain extent by the introduction of a remarkable type of Upland cotton known as Meade. The habit and behaviour of this variety resemble those of Upland cotton, but it produces lint of fine even quality, of $1\frac{5}{8}$ inch or more in length. This lint has been sold at Sea Island cotton prices, while yields have been obtained equal to those of short staple Upland varieties in the same districts, or two or three times greater than those of Sea Island grown under weevil infestation conditions.

It has been amply demonstrated that frequently crop maturity can be materially expedited by the use of fertilisers.

Due regard must also be paid to drainage, proper plant spacing, and general cultivation, for they also are factors conducive to early maturity as well as prolificacy; and, moreover, it costs as much for poison application to a low-yielding as to a high-yielding field.

Precautionary Measures Necessary.—As with all other arsenical preparations, a certain amount of danger to men and animals is associated with the use of calcium arsenate, and reasonable precautions must be exercised to protect those connected with its application. Personal cleanliness is primarily important; the hands and face should at least be cleansed after an application of the poison and before eating and drinking. Inhalation of the dust should be avoided as much as possible.

Animals engaged in these operations have suffered no injury, but it is considered desirable to keep ordinary wire muzzles on all animals employed in the poisoned fields.

Properly made calcium arsenate does not deteriorate, provided it is stored in a reasonably dry place. Under normal storage conditions it has shown no signs of deterioration after four years.

The Arizona Wild Cotton Weevil.—In 1913, Cook, *loc. cit.*, reported the discovery of a weevil breeding in the fruit of a wild cotton plant, *Thurberia thespesioides*, in the mountains of south-eastern Arizona; this was subsequently found to be a distinct variety, and it was described by Dwight Pierce as *Anthonomus grandis thurberiae*. Biological investigations showed that it interbred very readily with the Mexican boll weevil, thus demonstrating their close relationship.

The Arizona weevil has been under observation for several years. In 1920 it was observed attacking cultivated cotton plants near Tucson, Arizona. The State of Arizona is attempting to eradicate the insect by means of a non-cotton zone in the infested area. Tests conducted with the view to ascertain whether this insect exhibits any preference for either cotton or *Thurberia* indicated a slight preference at first for the latter plant, but this vanished after a few days' feeding. At the conclusion of the investigations it was decided that it displays no inherent preference for either plant.

Possible Introduction of the Boll Weevil to other Countries.—As regards the possible introduction of the boll weevil into other cotton-growing countries, significance attaches to the remarks of the chairman of the 5th Entomological Congress held at Pusa in February 1923. "Realisation of the fact that it [the boll weevil] has a very good chance of obtaining entrance into India, if it has not already done so, therefore comes to us rather in the nature of a shock"; and in view of the relatively large imports of American cotton for Indian mills, he added: "Fumigation of bales before shipment is neither practicable nor effective in ensuring that they will be free of weevils when landed".

In reply to inquiries made by the Indian authorities of the United States Bureau of Entomology, Dr. Hunter wrote: ". . . concerning the danger of the introduction of the boll weevil in India, I should like to make the following comments. The longevity of the adult boll weevil depends on seasonal conditions. In summer it rarely lives as long as fifty days. In the cooler portions of the year it has been known in numerous cases to live as long as six months. Therefore, as far as the time element is concerned, the establishment of the weevil in India by carriage on bales of American cotton would be a distinct possibility." (*Note*.—Bales in transit by steamers direct from New York take about one month; steamers via Japan about seven weeks, and via Liverpool five weeks.)

"The American cotton is wrapped in very coarse jute fibre. The covering gives many opportunities for the boll weevil or other insects to be carried. Many thousands of the weevils are concentrated around the gins each season, where

they may easily make their way to the bales which are lying on platforms awaiting storage.

"The reference works available indicate that the time of cotton planting in India varies from April in Punjab to October in Madras. With such a range in the development of the crop it is quite possible that hibernating weevils carried in bales of cotton would at least occasionally have an opportunity to infect the local cotton.

"Two courses would appear to me to be feasible in eliminating the danger incident to American cotton arriving in Indian ports. One would be to determine by certificates or warehouse receipts that the cotton was more than six months old; the other would be to have it fumigated with hydrocyanic acid gas as a condition of entry. It would not be necessary to have this fumigation in vacuum since the weevils are not to be found within the bales."

If the entry of American cotton to India were prohibited, there is not sufficient of this class of cotton produced locally to meet the demands of the Indian mills.

The Conference unanimously decided that neither certificates nor warehouse receipts showing the age of the cotton, as suggested by Dr. Hunter, would afford adequate protection against the weevil's entry into India, and that the advisability of the total prohibition of entry of American cotton should be considered. As an alternative, all bales of American cotton should be fumigated at the port of entry, and entry restricted to Bombay.

If there exists a danger of the weevil's introduction to India, a similar danger exists in regard to other cotton-growing countries that import American cotton.

THE PINK BOLL WORM

More than eighty years ago the pink boll worm was described by Saunders, from specimens sent to him from India, as *Depressaria gossypiella*, but it is now known as *Gelechia*, *Pectinophora*, or *Platyedra gossypiella*. It belongs to the order *Lepidoptera* and to the family *Gelechiidæ*. The specimens in question were collected in the Government cotton plantations at Broach, India, where it was reported to be very destructive by feeding on the seeds in the bolls.

Saunders published the first record of this insect in 1842. It was not until sixty-one years later that the next published statement regarding it appeared, when Vosseler reported it as injurious to cotton in East Africa. This introduction was probably effected in course of the trade between India and East Africa.

India and Southern Asia are considered to be the original home of the pink boll worm, and the wild and cultivated cottons its original host plants. It has also been found on okro, *Hibiscus esculentus*; Deccan hemp, *Hibiscus cannabinus*; *Abutilon*, and hollyhock, *Althæa*.

Its introduction into Egypt has been traced to shipments from India of seed cotton or defectively ginned lint between 1903 and 1910. The importation of lint cotton was prohibited by Law I. of 1916. Cotton seed had been prohibited since 1907. It is also known to occur in Australia, Brazil, Ceylon, China, Hawaii, Japan, Mesopotamia, Mexico, Palestine, Philippines, Straits Settlements, Sudan, United States, East and West Africa, West Indies, and Zanzibar.

Specimens of the pink boll worm were first collected in Egypt in 1910. It was not found to damage cotton until 1912, when it appeared in large numbers on an estate near Alexandria, and also in the Delta. Since that date the damage caused by it has steadily increased, despite the energetic and expensive control measures instituted by the Government.

Pink boll worm occurrence in Brazil and Mexico are likewise of comparatively recent date. As regards Brazil, it appears that during the years 1913-14 the Government imported considerable quantities of Egyptian cotton seed, which was distributed throughout the cotton-growing districts. The presence of an insect pest in the seed was not suspected, so it was not disinfected. As 89 per cent of the seed was found by a test for germination to be viable, it is considered probable that a certain proportion of the balance was infested with the pink boll worm. There thus appears to be little doubt but that the pest was generally established in Brazil by this means.

Two importations of Egyptian cotton seed were made into Mexico in 1911. It is probable that both of these were

infested with pink boll worm and contributed to the present infestation.

Description and Life-history. — The pink boll worm passes through four stages of existence. From the eggs, laid by the adult or moth, hatch out grubs or larvæ, which in turn change to chrysalides or pupæ, from which the adults emerge. In general appearance the adult resembles the ordinary clothes moth. It is dark brown in colour. The fore wings and the hind wings end in a sharp point, though the latter are broader than the former.

The eggs are oval in shape, very small and inconspicuous, with a finely wrinkled surface; they measure about $\frac{1}{25}$ inch long, and are about half as broad as they are long. When first laid they are white or faintly green, changing later to pale orange.

The newly hatched larva is glassy white with light-brown anterior markings. It grows rapidly and, when fully developed, measures about $\frac{1}{2}$ inch long. It is cylindrical in shape, white, with the dorsal side conspicuously pink tinted, and bears pale, moderately long hairs.

The reddish-brown pupa is about $\frac{2}{5}$ inch long; it is pointed at the posterior end, which is terminated by a hook-like process, and bears short, tawny-coloured hairs.

The female lays about 200 eggs, singly or in groups, on the leaves, bolls, and in the flowers of the cotton plant, which hatch in from three to twelve days. As many as 20 eggs have been found on a single boll.

As soon as it is hatched the larva bores its way into the boll. It commences to feed on the interior of one of the seeds; this is the food which it prefers, and when the contents of one seed is consumed it proceeds to the next one above. It confines its attentions to the one boll and makes no effort to reach another. Unlike the larva of the boll weevil, it does not discolour the lint of the boll that it attacks, and this is regarded as an important characteristic for distinguishing the two insects. Another characteristic which is of use in this connection is the habit of the resting larvæ of webbing two or more seeds together, when they are fully grown, for the purposes of protection. So firmly are these seeds webbed together that, generally, they are not separated when the cotton is ginned, and they provide a ready method of esti-

inating the proportion of infested seeds. In any case the resting larva protects itself from moisture and enemy attack by means of a silken cocoon.

The presence of the larva cannot be detected without opening the boll; this also serves to distinguish it from the larva of other boll worms, such as *Earias*, which are readily detected by the frass which they eject through the holes that they make in the bolls. When it is full-grown, it leaves the boll to pupate elsewhere, and usually on the ground under fallen leaves, bolls, or similar material. In the larval cocoon it is curled up, but in the pupal cocoon it lies straight.

A common boll worm which may be mistaken for the pink boll worm is *Chloridea obsoleta*, Fabr. The larva of this pest bores into the bolls and feeds for a short time, and then proceeds to another boll. In its early stages it is pink coloured, but when fully grown it is much larger than the larva of the pink boll worm, for it measures as much as 2 inches in length. It is, however, not found in the seeds, and it does not feed altogether in the interior of the bolls. The holes that it makes in the bolls are surrounded by a raised margin, and are much larger than the small circular holes made by the pink boll worm larva for the exit of the adult.

The larva stage of the pink boll worm extends for from nine to thirty days in the cotton-growing season, but later in the year it may be more or less protracted, for cold has a retarding influence on the larva. In Egypt some of the larvæ that are hatched from the October or November broods of moths remain quiescent as full-fed larvæ during the winter, and do not pupate until the spring or even the summer. From these pupæ some moths emerge in June and July, and others later in the year. Usually the pupal stage lasts from ten to twenty-four days. The pupa is enclosed in a silken cocoon, and may be found in the lint of an open boll, amongst dead leaves, or other trash in the fields.

Of the large numbers of moths that emerge in June from the spring pupæ, the progeny fly in July and August, and generation follows generation until the second half of December. Some of the larvæ of the last generation hibernate and carry on the life of the species. Others pupate and the moths emerge at the end of December or the beginning of

January, and apparently perish without propagating. The life of a moth generally lasts for two or three weeks. The period of a generation is thus seen to vary from a few weeks to more than a year. Dr. Gough found that, in Egypt, larvæ would remain dormant for over two and a half years. The experiments that he conducted indicate that heat is not a factor in controlling the æstivation or hibernating period of the larvæ, but that moisture combined with heat appears to be fatal to them.

In Honolulu cotton seeds infested with the larvæ of the pink boll worm were placed in small bales of cotton, and live larvæ were found in them up to eighteen months afterwards.

Of the conditions that influence certain larvæ to enter the resting stage nothing is known. Of the worms taken in the first picking of cotton, the short cycle kind predominates, but the resting larvæ predominate in the second picking of cotton. Many of the former and some of the latter develop into moths in the seed stores and, finding no suitable object on which to oviposit, are lost as far as the propagation of the species is concerned. The resting larvæ, left in bolls in the field, are able to pass the winter in bolls on the ground or buried in the soil, even if the ground is irrigated for other crops. It is found, however, that the moister the land is kept during the winter the more rapid the death-rate of the larvæ; also excessive watering, such as watering the land every two weeks, or a very heavy continual watering for a short period, increases the death-rate to a still greater extent.

This faculty of prolonging its existence throughout two growing seasons in this manner has doubtlessly materially facilitated its distribution to so many distant cotton-growing lands, and in Egypt is the principal means by which the species is carried over from year to year.

During the day the moths hide under stones or trash, and are difficult to disturb into flight and even to find, although they may be present in great numbers. The moth flies during the evening for the purpose of feeding, mating, and egg-laying. It appears to be most active shortly after sunset. Although it is capable of prolonged flight, it appears to be satisfied to reach the nearest cotton field.

In Egypt the moths seem to have displayed a certain amount of attraction to artificial lights, but in the Hawaiian

islands it has been found that lights, instead of attracting the insects, served to repel them. No great success has attended the efforts made in India to attract this pest or the *Earias* boll worm to lights.

Crop Injury attributed to Pink Boll Worm.—Injury to the cotton crop is effected in several ways. The lint of infested seeds does not develop normally and is short and weak. Sometimes one or more seeds, with their lint, are entirely suppressed. Infested seeds become unviable and lose their value for crushing. In England it has been ascertained that the oil in infested seeds is 20 per cent lower than normal, while the oil expressed from them is dark coloured and of comparatively low value.

The extent of the damage which the pest is capable of inflicting is well demonstrated by studies, conducted in Egypt by Gough, to ascertain the proportion of bolls attacked. From July to November, in one season, more than 100,000 bolls were examined. The percentage number of infested bolls at various periods was found to be as follows: July less than 10, August from 10 to 25, September 25 to 75, and October 75 to 89.

A conservative estimate of the loss to the Egyptian cotton crop attributable to the pink boll worm is given as 20 per cent. In some cases as much as 30 to 40 per cent of the seed has been damaged by the larvæ.

In Hawaii it has prevented the development of the cotton-growing industry, which originally showed great promise.

In Brazil, during 1917, the estimated losses sustained varied from 30 per cent of the crop, in the State of Alagoas, to 66 per cent in the State of Ceara, and a total valued at \$27,000,000.

In the same year the losses from the pest's ravages in Mexico amounted to 30 per cent of the cotton crop. In 1920 a commission that investigated the condition of the cotton industry, as affected by the pink boll worm, in the Laguna district of Mexico, reported the loss due to its ravages at 50 per cent of the cotton crop.

It is estimated that the ravages of the pink boll worm, *Earias insulina* and *E. fabia*, levy an annual toll on the Indian cotton crop, in normal years, of between 20 and 50 million rupees.

Natural Enemies of the Pest.—The pink boll worm has several insect enemies which aid in its suppression, but none seems at present to be of any great practical importance in controlling it. The pot-bellied mite louse, *Pediculoides ventricosos*, Newport, which is a common insect enemy throughout the world, is the most conspicuous. Warm, moist conditions appear to favour its multiplication. Labourers employed in handling Egyptian cotton seed at the London docks were affected by dermatitis caused by the punctures of this mite. In Brazil, children who frequent the vicinity of cotton-seed stores have been similarly affected.

In Egypt, besides the *Pediculoides* mite, three Ichneumonid insects have been found parasitising the pink boll worm; these are *Pimpla roborator*, *Chelonella sulcata*, and *Limnerium interruptum*. *P. roborator* is the only one that is sufficiently numerous to be of any great importance in checking the boll worm; but as it occurs so late in the season its value in this connection is much depreciated.

Microsporidium polyedricum, a protozoan parasite of the cotton worm, *Prodenia litura*, Fabr., is to be included with the above. The amount of mortality due to these parasites has been found to vary between 10 and 40 per cent.

Methods of Controlling the Pink Boll Worm.—In 1913 the United States promulgated regulations prohibiting the importation of cotton seed and cotton seed hulls from any foreign country, excepting the Imperial Valley in the State of Lower California; the importation from this region was already covered by regulations. Amended regulations permitted the entry of cotton seed from Mexico for milling purposes, for it was thought that no insects which were not known in the United States were found to occur there. Moreover, the cultivation of cotton in Mexico is more or less continuous with that of the United States.

During the same year 500 lb. of Egyptian cotton seeds imported into Arizona were found to be infested with the pink boll worm at the rate of 20 per cent, and the whole consignment was destroyed by fire.

It soon became evident that the regulations in force were not sufficiently drastic to prevent the introduction of this pest, for considerable quantities of seed were found in bales of imported Egyptian cotton. It was estimated that by this

means 16,000 live larvæ of the pink boll worm were being brought into the country each year.

Exhaustive studies were conducted with the object of discovering a feasible method of destroying any infestation in the bales of lint. The use of cold was found to be impracticable, as also was the use of heat, because of the time required to penetrate the highly compressed bales of Egyptian cotton, and because of the increased danger from fires when the heated bales were opened in the mills.

Experiments had demonstrated that insects in various plant products were more effectively destroyed by fumigating in a vacuum. The killing power of hydrocyanic acid gas is enormously increased in vacuum, so this method of attack was tested with regard to the Egyptian cotton bales. As the result of a long series of investigations, it was found practicable to fumigate, on a commercial scale, densely compressed bales of cotton, and to destroy the insects that they contained.

In 1916 it was required that all foreign bales of cotton should be fumigated in a specified manner, as a condition of entry. Large plants were erected for the purpose of fumigation at Boston, Oakland, California, New York, Newark, N.J., and Seattle. These establishments were found to be capable of dealing with all imported cotton without undue delay. The larger plants have a capacity sufficient to handle 1000 bales per day.

An order of the Federal Horticultural Board stipulates the procedure to be followed in the fumigation, and the kind of cyanide and sulphuric acid to be used is specified. Sodium cyanide is to be used at the rate of 6 oz. per 100 cubic feet. After the cotton is placed in the fumigating chambers the doors of the chambers are closed, and the air is exhausted until a vacuum of 25 inches is registered by the gauge. The gas is generated in a retort connected with the large chamber. The valve of the connecting pipe is opened, and at the end of fifteen minutes air is permitted to pass through the generator for five minutes, in order to remove any gas that may be present. The air valve in the fumigating chamber is then opened, and the air is permitted to enter until the gauge registers 5 inches. The cotton then remains in the chamber for one hour and forty minutes; so that the total process of fumigation extends for two hours. At

the end of this period the pumps are operated again to remove the gas, and a vacuum of 25 inches is established. The valves are then opened and the pumps are kept running for some time to complete the washing out of the gas from the bales. As soon as the pumps are stopped the doors of the chamber are opened and the cotton is ready for removal.

Manufacturing tests were carried out to determine whether fumigation with hydrocyanic acid gas injured the lint. The results demonstrated that no deterioration of the lint was caused by the fumigation as regards spinning qualities, tensile strength, percentage of waste, or bleaching, dyeing, or mercerising properties of the cotton.

In 1916 the term "cotton" in the regulations was amended to include all grades of cotton waste, excepting those resulting from manufacturing processes which render it mechanically impossible for it to contain seeds. This amendment was effected because considerable quantities of cotton waste were being imported, some of which contained twenty times as much seed as ordinary baled cotton.

In 1916, when the s.s. *Appam* was brought into Newport News as a German prize of war, she had on board 189 tons of cotton seed from Lagos, West Africa. As this seed was infested with the pink boll worm, it was decided to steep it in vats of sulphuric acid and thus make it available as a fertiliser. The two holds of the *Appam*, which contained the seed, were fumigated with cyanide, and the docks, lighters, trucks, floors, and platforms were thoroughly cleansed of seeds. Although repeated investigations were made of the cotton plantations near Newport News, so stringently were quarantine precautions exercised that no traces of infestation were discovered.

During the same year provision was made for the inspection and, where necessary, disinfection of all burlaps and other fabrics offered for import, which had been used for covering cotton, and to which cotton was adhering.

In 1917 an order was promulgated restricting the admission, from all foreign countries, of cotton-seed cake, meal, and all other cotton-seed products, excepting oil, in view of the possibility of their containing uncrushed cotton seeds infested with pink boll worm or other insect pests of cotton.

Notwithstanding all these carefully planned precautions,

cotton plants at Hearne, Texas, were found to be infested with the pink boll worm in 1917, and some in Louisiana in the winter of 1919-20. In Louisiana the pest appears to have been exterminated, while the infestation in Texas has been greatly reduced. In fact, it is considered probable that no nation has ever waged a more determined fight for the eradication of a single insect species within its borders than that which has been conducted since the discovery of the pink boll worm in Texas. That these activities are warranted is admitted, for in all probability, next to the boll weevil, the pink boll worm is the world's most serious cotton pest.

The United States authorities were unaware of the Mexican infestation of pink boll worm until 1916. An embargo on Mexican cotton seed was then immediately declared. Prior to this procedure, considerable quantities of Mexican cotton seed had been transported to various oil mills in Texas. Steps were taken to determine the possible presence of the pest in the vicinity of these mills, and to exterminate any pests discovered, as well as to enforce the quarantine regulations in regard to Mexican cotton seed and cotton products that might harbour the pest.

In connection with the measures adopted in Texas to eradicate the pink boll worm, twenty-five entomologists were employed in the Hearne district, and later about fifty entomologists were employed in south-eastern Texas. Their activities comprised scouting to determine the limits of the infestation, and the destruction of any possible infestation in the fields. The latter work included the cutting down or uprooting of the cotton plants, hand collection of all cotton locks or portions of locks found on the ground, and the burning of trash. In the course of this work nearly 9000 acres of land were cleared, which involved the employment of about 500 labourers from November to March.

By an act of the Legislature of Texas, in 1917, authority was granted for the quarantine of infested districts, and for the establishment of zones in which cotton planting could be interdicted. In January 1918 an area was quarantined within a radius of 3 miles from a mill at Hearne where Mexican cotton seed had been handled. In south-eastern Texas a quarantine zone 10 miles wide was established,

which included the limits of infestation in that region. Later a third non-cotton zone was established in the McKinney, Meverick, and Valverde Counties.

Activities on the Mexican border to prevent the importation of Mexican cotton seed comprise the inspection and disinfection of baggage, the cleansing or disinfection of all goods or vehicles in transit which are likely to carry infection. United States officials likewise co-operate with the Mexican Government and planters in stamping out the pest in Mexico.

From the vast amount of experience acquired in attacking the pink boll worm in the United States, investigators have arrived at the conclusion that the only effective method of exterminating this pest is by interdicting the planting of cotton in invaded areas for a period of years, or until all the insects have been starved out of existence.

Control Measures in Egypt.—In Egypt it is considered that the only stage in the life-history of the pink boll worm when it is controllable is that of the resting stage larvæ. These larvæ constantly increase in numbers as the season progresses, and are almost exclusively found in the seed of seed cotton, ginned seed, or in bolls left in the field. It is therefore with the view to attack the pest in this stage, and the moths emerging therefrom, that legislative measures have been enacted to enforce: (1) The collection and destruction of all cotton bolls left behind on the plants and on the ground after harvest, followed by the uprooting of the cotton, okro, and Deccan hemp plants, by a specified date, after the last cotton picking has taken place; (2) the treatment by fumigation or heat of the seed in the ginneries; and (3) the screening of all stores, where seed cotton or cotton seed is present, in the period from May to August.

It is, however, appreciated that the strictest application of these measures will not eradicate the pest, for large numbers of bolls that fall to the ground will always escape destruction. All that can be reasonably expected is to keep the pest in check and to reduce the infestation.

After testing various methods of destroying the larvæ in the seed, one by which heat is the destructive factor has been finally adopted as the standard. One apparatus employed in this connection comprises a furnace for generating the hot air, a chamber through which the seed is passed, and a motor.

The hot air chamber consists of a rectangular iron box, insulated on the outside by asbestos to prevent the loss of heat. Within these are four endless iron-chain bands, fitted with trays to carry the seed. An automatic hopper feeds the seed into the top of the machine, and drops precisely the amount of seed required to form a layer, one seed deep, on the endless bands. After completing the circuit, the seed is discharged into an Archimedean screw conveyor, which takes it to the sacking exit. Air is circulated through the machine by means of a fan. The opening or closing of a damper, situated between the hot air generator and the hot air chamber, regulates the temperature in the chamber. The best temperature to regulate the machine for is 50° C., while that of the seed at exit should be between 48° C. and 55° C. This machine successfully kills all the worms in the seed without interfering with the seed's germinating powers. The output of this machine was too small to justify its adoption on a commercial scale.

Simon's malt-drying machine, when fitted with an automatic feeder, overcame this objection, and proved remarkably successful.

Law No. 29 of 1916 orders every ginnery to be equipped with a machine, operated to the satisfaction of the Ministry of Agriculture, for the destruction of worms in cotton seed. Contravention of this order is punishable by a fine or imprisonment, and the stoppage of the ginnery from working. The promulgation of this Law caused many machines to be brought forward for the treatment of cotton seed.

One of these, known as the "Delta", complies with the Law's requirements, and has been approved by the authorities, and adopted by some of the gineries. It consists of three cylinders, placed one above the other, steam-jacketed on the lower half, and opening by a lid on the upper half to facilitate the cleaning of the cylinders. The seed enters at one end of the uppermost cylinder through an automatic feeder and, after passing through the three cylinders, is discharged at the opposite end of the bottom cylinder. Each cylinder is furnished with a revolving framework; this carries on its circumference a spiral band which propels the seed along the cylinder, while a number of horizontal bars keep the seed in constant motion. Later models of the machine are equipped

with only one cylinder, which is equal in length to that of the three cylinders of the earlier model.

The operation of the machines is controlled by germination and worm tests. For this purpose samples of treated seed are sent by the ginner to the Entomological Service, and occasional surprise samples are taken by agents of the Service. Ginners are notified by the Service of damaged seed and living worms discovered. Altogether the enforcement of the Law has not presented any special difficulties.

The same Law likewise regulates the storage of seed cotton and cotton seed during the months of May to August, during which period these products may only be kept in licensed stores. Licences for this purpose are only granted, after inspection, if the stores are properly moth-proof. The windows must be screened with wire gauze or cloth, and the doors must be kept closed at night. There is little fear of the moths escaping through open doors or windows during the day, owing to their habits, as already described.

In the scheme of planting in Egypt, cotton is followed by bersim (clover), which is irrigated; still cotton bolls, which contained live larvæ, have been dug up from ground under bersim cultivation. This indicates that the larvæ will not only survive after being ploughed underground, but even after such ground has been irrigated. Bolls which were buried in the ground in January to a depth of from 2 to 4 inches were found to contain live larvæ at the end of July.

The importance of destroying plants and bolls as early as possible in the season is specially urged, in view of the greater proportion of resting larvæ that appear as the cotton season progresses. Indeed this is the primary factor upon which the control of the pink boll worm centres.

The dates for the removal of the bolls on the plants, after the last cotton picking, have been fixed as follows: 10th November for Upper and Middle Egypt, and part of the Delta; 20th November for the Middle, and 30th November for the north of the Delta. The convictions of the Entomological Service are, however, to the effect that these dates might be advanced with advantage, for every day after the 1st October matters very considerably. Also, that it is false economy to allow the comparatively minor losses of the small number of farmers whose crops are backward to be used as

an objection, when much more serious losses to the entire community are thereby likely to be caused in the succeeding season.

Varieties that mature their cotton late in the season have practically all their seeds destroyed by the pest, while those that mature earliest produce the highest percentage of viable seed, for it is less affected by the pest. In fact, the pink boll worm has been primarily responsible for the much earlier maturity of the Egyptian cotton crop of recent years. Prior to 1910 cotton was cropped from September to January, but at the present time there is practically no cotton capable of being picked as late as November.

Legislative measures for the control of this pest are now enforced in nearly every country where it is known to exist, and for the most part these measures resemble those obtaining in Egypt. They are, however, merely palliatives, and cannot possibly effect the extermination of the pest. The only feasible method of exterminating the pest appears to be the interdiction of cotton cultivation, and the eradication of other host plants, in defined zones until the pest has been starved out. Zones cleared of the worm in this manner should then be protected from re-invasion by the disinfection, by fumigation or heat, of all material entering the zone which is likely to introduce the pest.

THE AMERICAN BOLL WORM

This boll worm is the larva of a moth *Chloridea obsoleta*, (*Heliothis armiger*) Hübn. It is one of the most cosmopolitan insect pests, and is found in nearly all temperate and tropical countries. Whether it is indigenous throughout this wide range, or whether it has been carried from one or more points, it is not possible to say. Besides its injury to cotton, it is a serious pest of maize, and in a lesser degree of tobacco, tomatoes, lucerne, beans, and peas, and many other crops as well. In the United States it was well known as a most destructive and widely distributed cotton pest, long before the boll weevil made its appearance. Several years ago its ravages were estimated to cause an annual loss to the United States cotton crop of 8½ million dollars, and its damage to all crops at 30 million dollars.

Description and Life-history.—The female moth lays her eggs, at twilight, on all parts of the cotton plant, but they are found most abundantly on the under surface of the leaves. The eggs are convex in shape, with parallel, longitudinal ridges radiating from the centre above. In colour they are yellowish white. They hatch in from two to seven days.

The newly hatched larva is yellow or pale green in colour. It commences to feed near its egg-shell, and then crawls away in search of a young flower bud or boll, into which it bores and feeds on the interior. Having completed its work of destruction, it bores another hole for its exit, and proceeds to a fresh bud or boll, and so on. The involucre of a bud or boll attacked in this way flares open, and the bud or boll falls to the ground. In certain cases the worm's attack on a bud causes the flower to open prematurely, but the worm then eats and destroys the stamens and pistil.

The appearance of the worms changes as they grow older. When they are full-grown they vary in colour from light green to dark brown, and they may be black spotted, dark striped, or not marked in this way at all. As the worm grows larger it attacks the larger bolls. It is a voracious feeder, and is not always content with a vegetable diet, for the larger worms feed upon the smaller ones.

The larva takes from two to four weeks to become full-grown; it then enters the ground to pupate 2 or 3 inches below the surface. It covers itself with an oval-shaped earthen shell, similar to that made by the pupa of the Egyptian cotton worm, which it forms of earth particles held together by loose, gummy silk. The pupa is a light mahogany colour. The period of pupation is from one to four weeks.

The general colour of the moth varies from ochre-yellow to dull olive-green, with dark bands and spots. It measures about $1\frac{1}{2}$ inch across the outstretched wings. Normally it flies at dusk and feeds upon the nectar of cotton and other flowers. The female lays about 500 eggs. During the day-time the moth hides in clover, cowpeas, or some similar sheltering plant near the cotton. When disturbed it flies low with a quick darting motion.

The average time occupied by the insect in its transforma-

tions from the egg to the adult moth is about forty days, and generally there are five generations in a season. Usually the early generations feed on maize, and the later generations on cotton.

Hibernation principally takes place in the pupal stage underground.

Methods of Control.—This pest has several insect and bird enemies, but none of them appears to be very conspicuous in checking its ravages.

Beneficial results have been obtained by planting early trap crops of maize.

Autumn and winter ploughing, and frequent cultivation of the growing crop, effectively destroys many pupæ, and exposes others to the attacks of insects, birds, and rodents, and also to the deleterious action of frost, rain, and sunshine.

The use of arsenical poisons is efficacious. The application of calcium arsenate, in the manner described for boll weevil control, should prove equally effective for controlling this pest. Practically all the methods recommended for controlling the boll weevil are applicable in this case also.

During investigations into the binomics and incidence of the pink boll worm at Coimbatore, India, *Chloridea obsoleta* was found to be committing considerable damage to cotton, in fact more havoc than the two *Earias* boll worms and the pink boll worm put together. Prior to this it did not appear to damage the cotton crop in India. At the time of the investigations there were 15 acres of Bengal gram, *Cicer arietinum*, on the farm and some tobacco plants next to one of the attacked cotton fields. The tobacco was not touched, but the gram was almost a total failure. If it persisted in this change of habit, *Chloridea* might prove a far more dangerous pest than the three boll worms mentioned.

EARIAS BOLL WORMS

The Spiny Boll Worm.—The spiny boll worm, *Earias insulana*, appears to have made itself most conspicuous as a cotton pest in Egypt. It was probably introduced into that country from India, where it is also destructive to cotton. In Egypt attention was first drawn to its ravages by Jannovitch Bey in 1873. In addition to these two

countries it has been recorded from Crete, Sicily, and Spain in Europe; North, South, East, and West Africa, as well as the Canaries, Madagascar, and Mauritius; Baluchistan, Burma, Siam, and Syria in Asia; Queensland in Australia. It is the caterpillar or larva of a Noctuid moth which causes the damage by boring into, and consuming the contents of, cotton bolls, shoots, and flowers.

Description and Life-history.—This insect belongs to the family *Noctuidæ*, to the sub-family *Acontianæ*, and to the genus *Earias*. Its life-history in Egypt has been recorded by Willcocks.

The egg is almost round and about 0.5 mm. in diameter. At first it is turquoise blue or bluish-green in colour, but later the greenish tint prevails, and a brownish ring appears around the upper third of the egg and a similar coloration in the centre. On the surface are numerous prominent, vertical, and slightly zigzag ribs.

Oviposition takes place on various parts of the cotton plant, such as the bolls, squares, and terminal buds. Eggs are also laid on several species of *Hibiscus* plants, viz. *H. cannabinus*, *H. esculentus*, *H. mutabilis*, and *H. rosasinensis*. In India *H. esculentus* appears to be even more favoured than cotton. Oviposition takes place at night; generally only one egg is laid by each female on a boll, but several other females may oviposit on the same boll. One female, which was kept under observation in a laboratory, laid a total of more than 200 eggs in five consecutive nights.

As larvæ, in all stages of growth, eggs, pupæ, and adults are found at the same time, in one field, throughout the summer months, it follows that the egg-laying period is not by any means of short duration.

The eggs hatch out in three or four days in the summer, and in eleven or twelve days in the autumn and winter. Shortly after it is hatched, the young boll worm bores into a boll, square, or terminal shoot. The larval stage lasts for about two weeks in the summer, but in the autumn and winter, when the temperature is lower, growth proceeds at a much slower rate, and the larval period is considerably prolonged.

The mature larva is about 15 mm. (0.6 inch) long; its anterior portion is thick-set and tapers towards the anal end.

It has a "hunched-up" appearance, which is specially noticeable when the larva is at rest. In colour it may be reddish brown, sometimes purple tinged, with orange markings, or green with similar markings. Numerous fleshy spikes on the body give it a characteristic appearance. The skin is covered with minute hairs.

On reaching maturity the larva leaves the boll in which it has been feeding, and spins a boat-shaped cocoon between two of the involucre bracts or between a boll and its involucre, but not necessarily on the boll in which it has fed. They also pupate in cracks in the ground, and spin their cocoons on the weeds that grow amongst the cotton. The closely woven silk of the cocoon varies in colour from white to dark brown, and is felt-like in texture. The yellowish-brown pupa is 9 to 11.5 mm. (0.4 to 0.5 inch) long. The pupal stage lasts from ten to fourteen days in the summer, but in the autumn and winter it is much prolonged. Larvæ which pupate in December and January may remain quiescent for two or more months.

The moth measures about 22 mm. (0.9 inch) in expanse and the body is about 9 mm. (0.4 inch) long. The colour of the fore wings is green, chrome, or brown; that of the hind wings is white with pale brown margins. The green forms are numerous in the summer and early autumn, while later in the year the yellow and brown forms are most abundant. These colour variations coincide with the seasonal colour changes of vegetation, and suggest a protective measure for the insect's preservation.

The moths find shelter during the daytime between a boll and the involucre, and in weeds near the cotton fields. Sometimes they are found at rest on a leaf fully exposed to the sun, and occasionally they may be taken *in coitu* on such leaves. Unless they are disturbed they do not fly until night, when their flight is slow and wavering.

After the cotton is picked some of the larvæ remain in the bolls on the plants, and continue to feed upon the seeds. Many of them eventually arrive at maturity, and leave the bolls to pupate amongst the dried leaves and stems. They remain in this condition until warmer weather causes the moths to emerge, and these deposit their eggs on any food plants that may be available.

Damage done by the Spiny Boll Worm.—In Egypt the degree of damage done by the pest appears to be almost entirely dependent upon whether the cotton crop is late or early, for it is generally found that great damage is done when the crop is late and little when it is early. Early in the season, when no buds, flowers, and bolls are to be found on the cotton plants, the boll worm attacks the terminal shoots. It bores a hole near the tip of the shoot, and eats a tunnel down the centre of the stem until the woody portion of the stem is reached, when it leaves the stem in search of a fresh young stem. Shoots attacked in this manner wither and die.

As soon as the flower buds appear, they are attacked in preference to the shoots. Attacked squares present a "flaring" aspect, similar to that already referred to in connection with the boll weevil's depredations. Flared squares usually fall to the ground as a result of the injury, while the larva leaves the bud in search of another victim.

Flowers are frequently rendered sterile through the larvæ feeding on the reproductive organs.

Larvæ that bore into cotton bolls protect themselves from attack by parasites, by voiding moist excreta into the passage which they make for their own entry. In the course of a larva's operations one or all the cells of a boll may be destroyed. Medium-sized bolls that are attacked often die and remain attached to the plant in a dried-up state. Large bolls that are attacked open prematurely, and the lint becomes damaged by exposure.

Some conception of the amount of damage which the pest is capable of causing may be obtained from the estimate made by Dudgeon to the effect that a single female moth that commences to lay in January might be responsible for the production by the fifth generation in the following October of $3\frac{1}{2}$ million boll worms, of which, at a moderate estimate, $1\frac{3}{4}$ million would survive to become mature. In years of severe attack the Egyptian cotton crop has been depleted to the extent of 18 per cent by this pest.

Nature's Methods of Control.—Several insects are known to parasitise this boll worm. In India, *Rhogas Lefroyi*, Dudgeon and Gough, a hymenopterous parasite, is conspicuously destructive in this respect. Specimens of it were introduced to Egypt by the Egyptian Government in 1912. The import-

ance of this introduction was, however, depreciated through the discovery later, in Egypt, of an indigenous and nearly allied parasite, *Rhogas Kitcheneri*, Dudgeon and Gough.

Prof. Lefroy conducted experiments in India with the first-named parasite, by propagating and introducing it into cotton fields infested with the boll worm, and a large decrease in the number of attacked bolls resulted. But the difficulties associated with the propagation of the parasite on a large scale were found to be too great for this method to be generally adopted as a practicable remedial measure. In Egypt better results are anticipated from the steps taken to introduce, to new localities, larvæ infected with the parasite and pupæ of the parasite, and by this means encourage colonies of the parasite to establish themselves naturally.

Ants have been observed to eat through the cocoons of the boll worm, and to devour the pupæ, but no great benefits are expected to accrue from their activities.

Mechanical Methods of Control.—Owing to the fact that the larva feeds in the interior of the boll, the application of insecticides is impracticable. At present the greatest efficacy in control is expected to be derived from the methods enforced by legislation. The laws promulgated provide for the collection, and destruction by fire, of all bolls left on the plants after the crop is gathered, and the subsequent uprooting of the cotton plants by a fixed date.

Damage in India by E. fabia.—In India *Earias fabia* is even more prevalent in certain districts than *E. insulana*. Early in the season its presence is made conspicuous by the withering of young top shoots which it has attacked. The larvæ bore into both flower and leaf buds as well as bolls, but when these are not available, it attacks the top growths. More bolls are bored into than are actually fed on. In some cases, after boring into a boll, the seeds are only just nibbled and the boll is abandoned for another. During rainy weather, water collects in such bolls and sets up decomposition, which causes them to rot and fall to the ground. Slightly affected bolls do not open properly, and the value of the lint is diminished through lack of uniformity, strength, and glossiness.

It is estimated that the depredations of the pink boll worm and the two *Earias* boll worms just mentioned levy

an annual toll on the Indian cotton crop of between 20 and 50 million rupees.

The larvæ of *E. biplaga*, Walk., and *E. cupreoviridis* attack cotton bolls in Nigeria.

THE SUDAN OR RED BOLL WORM

The Sudan or Red Boll Worm, *Diparopsis castanea*, Hamps., appears to be confined to the African continent. In South Africa it is reported to account for the destruction of 60 per cent of the cotton bolls. It is a serious pest of cotton in Nyasaland, Rhodesia, Sudan, and West Africa.

Description and Life-history.—The eggs are very small, 5 mm. (0.2 inch) in diameter, and are pale blue in colour. They are laid indiscriminately at the base of a bract, on the stem, leaves, or involucre, but commonly on the young terminal leaves.

The larva hatches out in three days, and at first is pale yellow; when full-grown it is about an inch long, pale green in colour with bright pink markings, shaped like the broad arrow on the dorsal aspect of each segment. It takes about three weeks to feed up, when it leaves the boll, crawls down the stem of the plant, and buries itself 2 or 3 inches below the surface of the ground, forming a cement by means of a secretion and particles of earth to make a cocoon.

The pupa is short and fat, about half an inch long, and is enclosed in the earthen cocoon already mentioned. It is pale yellowish-brown in colour. The pupation period is ten days, so that the whole life-cycle from egg to moth is about one month.

The adult moth is small and inconspicuous. The abdomen and hind wings are a light pink colour; the head, thorax, and fore wings being dark reddish-brown, with indistinct pale markings.

Shortly after hatching from the egg, the larva enters the nearest boll by boring through the fruit wall, and proceeds to devour the contents.

Affected bolls are usually discoloured, and if the bracts are turned back a hole will be seen, which is stopped up by the grub's excrement; sometimes the bracts are firmly stuck to the boll by it.

As a control measure, all affected plants and bolls should be destroyed after harvest, and the land should be ploughed up and cultivated thoroughly to pulverise the soil and expose the pupæ to atmospheric influences and their natural enemies.

Various Boll Worms.—The bright pink larvæ of the moths *Gnorimoschema sp. nov.* and *Pyroderces simplex*, Wlsm., are commonly found attacking cotton bolls in Nigeria, and the last mentioned is also found in Gambia and Egypt.

There is a considerable resemblance between the moths of these two species. The former has dark-brown fore wings, with three very noticeable pale markings and almost white hind wings. The latter is small, inconspicuous, brown, with smaller and less defined markings than the former.

Both insects are subject to attack by Chalcid parasites, and both pupate in the cotton boll in a light silken cocoon in the midst of a mass of excreta.

The Corn (maize) Ear Worm, *Laphygma frugiperda*, S. & A., is also a boll worm pest in the West Indies. The larvæ feed on the leaves and have to eat their way into the bolls. Paris green is applied as a control measure.

STAINERS

In addition to the boll worms that attack the interior of the bolls, the bolls are subject to external attacks by various sucking bugs, of which species of *Dysdercus*, the red stainers, are most prominent. They are reported to have caused the abandonment of the cotton industry in the Bahamas in the early days, while *D. Delauneyi* is described as the most serious insect pest of cotton in the West Indies to-day.

The Genus Dysdercus.—The genus *Dysdercus* contains over 70 species, and some 22 of these have been recorded as cotton feeders, the only important cotton-growing areas that are free from them being Egypt, South Russia, and Iraq.

The general colour of the insects is red, but various forms of black or white markings are shown in different species and at different periods of a particular insect's development. All *Dysdercus* stainers are more or less alike in habit; for choice they feed on the seed in the growing cotton bolls, but also on the leaves and tender stems, and they swarm in buildings where cotton is stored.

D. cingulatus in India.—In India *D. cingulatus* is common throughout the plains, where it feeds on Malvaceous plants, and when the conditions are favourable it is found in abundance in cotton fields, especially when the crop is ripening.

The insects are a vivid red colour, with a black diamond mark on the wings and some white lines on the lower surface.

A mass of little, round, yellow eggs is laid on the soil or on a cotton boll.

The young are wingless, coloured brilliantly red, and run about actively, feeding by sucking the juices of the leaves until the bolls appear. They develop rapidly, and wings appear after the third moult. The full-grown insect rarely flies, but it runs actively. Its long suctorial beak is able to enter the boll and suck out of the seeds.

Not much damage is done to the plant, and its principal injury to the boll is not visible until the cotton is picked. The damage is then apparent by light seeds that have been sucked by the bug, inferior lint due to young seed injured by sucking, and stained lint. Injury to the lint is also caused by staining due to insects that are crushed in ginning. In some cases, as much as one-third of the lint is damaged by stainers. Not only is there a loss of weight due to injured seeds, but many seeds look quite normal on the surface, and the injury is not seen until they are cut open ; such seeds fail to germinate and are of little value for oil extraction.

Dysdercus spp. in West Africa.—In West Africa stainers suck the juices of a variety of plants, especially *Malvaceæ*, maize, Guinea corn, and even wild grasses.

In Nigeria, *D. supersticiosus*, Fab., is the most common stainer on cotton, and it occasionally interbreeds with *D. melanoderes*, Karsch, which is far less common. Other species present are *D. nigrofasciatus*, Stal., and *D. intermedius*, Dist. The entomologist of the Agricultural Department has recently re-investigated the cotton stainer problem in Nigeria.

Although four new species of Dipterous parasites have been discovered, the larvæ of these flies do not appear seriously to affect either the longevity or fecundity of the stainers. Several species of *Reduviid* bugs, *Phonoctonus picturatus*, Fairm, *P. fasciatus*, P. de B., and one, probably *P. formosus*, Dist., are exclusively predatory on the *Dysdercus*, each adult consuming about three stainers daily. Still it has been

found impossible to increase in the field the ratio of *Reduviids* to stainers to any great extent, by breeding them in the laboratory and liberating them.

It is interesting to observe that while the stainers have many food plants, they only appear to breed when fed on seeds of cotton, silk cotton, *Eriodendron anfractuosum*, DC., okro, *Hibiscus esculentum*, Linn., and possibly seeds of another Malvaceous plant, *Abutilon zanzibaricum*, Boj.

The stainer inserts its rostrum between the carpels and sucks the soft seeds, causing the seeds to wither, and the lint to be stained from the base outwardly; but staining due to voiding excrement is considered negligible. Moreover, it has been observed that after the seed becomes hardened no staining resulted. Voided excrement remains as a tiny globule, usually drying and leaving little trace, and does not spread and become absorbed by the lint. Only before the seeds are mature and before they harden can staining occur. Even when kept under observation for one month, and ripe bolls were continuously attacked by stainers daily sucking the oil from the seeds, no staining was observed.

Although a considerable number of squares are shed by unprotected plants, still stainers have not been seen feeding on the squares.

Life-history of D. superstitiosus, Fab.—The eggs are oval, cream coloured, and 1 mm. (0.04 inch) long. Batches of eggs are laid in cracks in the ground, in shady places under rubbish or grass; probably for protection, the eggs are usually covered with a layer of earth $\frac{1}{2}$ an inch to 1 inch deep. There is an average of 3 to 4 ovipositions, with an average of 64 eggs per oviposition; the total average per female being 237 eggs, the minimum being 70 eggs, and the maximum 462 eggs. The eggs do not resist the effects of desiccation and direct sunlight, while too much moisture is also injurious. A temperature of 75° F. in the shade, with humidity resulting from heavy evening and morning dews, appear to be the optimum natural conditions.

The average life-cycle is from thirty-six to forty-six days, and as adults may be seen *in coitu* throughout the year, there may be as many as eight generations in one year.

The average incubation period is five and a half days. *Phonoctus* parasites attack the stainers at all stages from a

few hours after hatching, impaling the stainers on their beaks and sucking out the juices. These parasites mimic the stainers to a most extraordinary extent.

On hatching from the egg, the nymphs are salmon pink, but they soon change to a bright vermilion.

It is suggested that *D. supersticiosus* is the principal cause of the poor quality and low yield of Southern Nigeria cotton.

The control measures recommended are a close season for cotton and the elimination of alternative hosts.

Transmission of Disease by Stainers.—In addition to the above-mentioned damage caused by stainers, by some means not yet thoroughly understood, they convey bacterial and fungoid disease from boll to boll as they feed, such as the internal boll disease, which causes a staining and rotting of the lint, thereby considerably reducing its value and its quantity.

DUSKY BUGS

The Dusky Bugs, *Oxycarenus spp.*, have been frequently confused with *Dysdercus* stainers, whereas they are seed bugs. They are specially prominent in Africa, and also in India, Burma, Australia, and South America, seven species being known to attack cotton. *O. hyalinipennis*, Costa, has been known in Egypt since 1860.

Life-history of O. hyalinipennis.—According to Kirkpatrick (Bull. Min. of Ag., Egypt, No. 35/23) *O. hyalinipennis* is abundant in Lower and Middle Egypt and also in Sudan.

The minute oval eggs are yellow at first, but turn pink later. All immature stages of the insect are wingless, the head and the thorax being brown and the abdomen pink. When the adult first emerges it is pink, but it soon turns black. It breeds on several species of *Malvaceæ*, and as this cannot take place when seeds of a host plant are not available, it commences to attack cotton as soon as the first bolls open.

The eggs are usually laid in the lint, but occasionally on green bolls; the average number of eggs laid per female is twenty. The bugs die shortly after oviposition. The incubation period varies with the temperature prevailing from four to forty-three days, 35° C. being conducive to

the shorter period and 14.6° C. to the longer period. Above 37.8° C. they fail to hatch.

All stages of the insect feed on the seed, though occasionally they drink dew and suck the plant glands to obtain moisture. The life-cycle from egg to egg is about twenty days, and there are three or four generations in a season.

At the end of the breeding season, the adults become quiescent first on cotton and then on trees, grass, and weeds. They are not entirely inactive in the winter, for on warm days they fly to plants and suck sap. At this period they are not attracted to cotton seed.

Damage by Dusky Bugs.—In young cotton they are occasionally found sucking the leaf glands, but are for the most part quiescent. Many do not appear in the cotton until the bolls are ripe, for in the absence of food copulation is sterile. At the end of the breeding season, they occur in cotton in enormous numbers, estimated as high as 12 millions per feddan (1.038 acre). The bugs do not cause the shedding of buds or young bolls.

Attacked seeds are not recognisable externally, but when these are cut open they exhibit a discoloured and shrivelled embryo. The loss in seed weight due to attack varies from 2 to 15 per cent; the financial loss in Egypt from this cause alone is estimated at £100,000 per annum, but it is conceivable that the ginning out-turn may be considerably raised. In the case of severe attack, germination is affected to the extent of 75 per cent of seeds rendered useless. Lint damage is of secondary importance; it becomes discoloured if the seed cotton is ginned soon after picking, owing to the presence of the bugs. If the seed cotton is left for ten days, all the bugs are dead and dried up, and no staining results from them. No staining results from the bugs' excrement.

The bug appears to be immune from parasites and predatory enemies, so that the obvious methods of control are the elimination of its winter haunts, the destruction of the insects on tree trunks, the destruction of weeds, and traps of seed cotton in the early summer. Seed damage may be greatly curtailed by the early picking of seed cotton; and lint damage may be eliminated by spreading the seed cotton in the sun to aid the escape of the insects, and by storing the seed cotton for at least ten days before ginning.

O. lætus in India.—In India the attacks of *O. lætus* not only lower the vitality of cotton seeds, and injure the lint, but introduce a number of fungoid and bacterial diseases into the boll. The insect does not enter the unopened bolls, but its most severe injuries follow the attacks of the boll worm.

In addition to *O. hyalinipennis*, *O. Dudgeoni* is likewise troublesome in West Africa.

Various Plant Bugs.—In Egypt, *Creontiades pallidus* is found from May to August; it then disappears, to reappear at the end of the cotton season. Its life-cycle is rapid and is completed within three weeks. It feeds on buds, and causes a considerable shedding of those which are of medium and large size. Both this insect and the Green Stink Bug, *Nezara viridula*, L., feed on green bolls; in the case of small bolls it results in shedding, and in larger ones the premature opening of the bolls and the destruction of the lint. The direct damage to the seed is not great. In the existing state of the knowledge of these two pests, the only feasible methods of attack are clean cultivation and the hand-picking of *Nezara*.

Nezara viridula is a minor pest of cotton in India, West Indies, and Porto Rico. In St. Vincent it is suppressed by egg parasites, but it is suspected of carrying the internal disease of cotton bolls.

The small Red Plant Bug, *Graptostethus servus*, F., is a minor pest in India and Burma.

The Rutherglen Bug, *Nysius vinitor*, Bergroth, is common in Australia, where it feeds on a variety of plants besides cotton. The adult is small and brown with silvery grey, gauzy wings that are folded flat on the back. It is very active and sucks sap from the stem and the foliage as well as the boll.

LEAF-EATING INSECTS

EGYPTIAN COTTON WORM.—The Egyptian cotton worm is the larva of a night-flying moth, *Prodenia litura*, Fabr., which belongs to the family *Noctuidæ* and to the sub-family *Acronyctinæ*. It feeds on the leaves, buds, flowers, and fruits of a variety of herbaceous plants. In India it is a pest of tobacco and castor-oil, but does not attack cotton. In West Africa it shows a partiality for maize.

Although at different periods it has caused a good deal of damage to the cotton crop in Egypt, it shows no preference for cotton, and when other food-plants are abundant it refrains from feeding on it to any large extent. Food-plants in Egypt that are especially attractive are clover, beans, and vetches. Prior to 1877 it does not appear to have been abundant, nor to have caused any serious damage to cotton. It is considered possible that this pest was introduced to the country with cotton, and that until 1877 its activities were mainly confined to its other food-plants. In consequence of the restricted water supply, the latter were not, however, abundant throughout the year. The improvement in the conditions for plant growth, brought about by increased facilities for irrigation, enabled the cropping of clover to be prolonged and the area under cotton to be extended. The worm was thus afforded opportunity to adapt itself to the new food and to multiply abundantly.

According to Ahmed Zaki Pasha, it was originally a pest of clover, and the sparse supply of water available for cotton kept it in check until 1879. During this year the summer water supply was particularly favourable, and cotton was attacked. Since that date, provided that climatic conditions were conducive to its development, it has been sufficiently abundant to reduce the crop materially.

Wide Distribution.—This insect has a wide distribution, for it has been recorded from the following places :

Europe : Crete, Turkey.

Asia : Borneo, Ceylon, China, Christmas Islands, Cocos-Keeling, Formosa, Japan, Java, India, New Guinea, Persian Gulf, Singapore, Syria.

Africa : Ascension, Canaries, Congo, East Africa, Egypt, Gold Coast, Madagascar, Madeira, Mauritius, Natal, Nigeria, Rhodesia, Rodriguez, St. Helena, Sudan.

Australasia and Pacific Islands : Caroline Islands, Fiji, Gilbert Islands, Marquesas Islands, Marshall Islands, Navigator Islands, New South Wales, Queensland, Sandwich Islands, Society Islands, Tahiti.

Description and Life-history.—A full description of this insect's life-history in Egypt has also been published by Willcocks.

Eggs are laid in masses of about 600 each, although they

may contain as few as 120 and as many as 1250 eggs. Each mass is covered with pale brown down. The eggs are yellow in colour. On cotton they are commonly laid on the leaves, the under surface being preferred. The incubation period lasts from two to five days. Preference is shown for newly irrigated plants, so that some farmers abstain from irrigating when the egg-masses appear.

The young larvæ feed principally on the lower epidermis of the leaf, which, as a result of their activities, is given a lace-like appearance. Later they attack buds, flowers, and young bolls as well. During the heat of the day, they shelter beneath dried leaves on the ground and in crevices in the ground, and emerge to feed at night or on cloudy days. The young larva has a greenish body with black tubercles, and a shiny black head. The colour of the full-grown larva varies from olive-green to purplish-brown; at this period it is cylindrical in form and about 4 cm. (0·2 inch) long. During the summer, the larva lives for about fourteen days, but later in the year it lives much longer.

When it is full-fed it buries itself in the ground, usually at the base of its food-plant, and forms an earthen cocoon in which it pupates. The pupa is a reddish-brown colour, and measures about 16 mm. (0·7 inch) long. This stage lasts from seven to fourteen days in the summer, but for a longer period later in the year.

The emergence of the moth is sometimes delayed if the soil is too dry for it to force its way through. On the other hand, large numbers of pupæ are destroyed if the ground is irrigated shortly after pupation takes place, for this stops up the channels of emergence, and the surface soil becomes sun-baked. The moths bred early in the season are usually larger and more robust than those bred later, but the later broods are often brighter coloured. In expanse the moths vary from 32 to 50 mm. (1·3 to 2 inches). The fore wings are pale brown, while the hind wings are white with an outer margin of brown.

Controlling Factors.—In 1904 the Egyptian Government was urged to take steps to minimise the attacks of the pest. A decree was promulgated in the following year which, very briefly stated, provided for the picking and burning of all leaves bearing eggs of the cotton worm. In a report for 1905

of the organisation responsible for the execution of the provisions of the decree, it is represented that "the cotton worm, which had hitherto done such a vast amount of injury, has this year done absolutely none".

The first generation of worms in 1906 was abundant, but the second and third generations were controlled by natural factors. Similar conditions obtained in the following year. In each of the two succeeding years, the worms increased through three generations. In the year 1909 they were described as "moving like a stream, and devastating everything before them: leaves, squares, buds, flowers, and bolls".

In 1911 many of the worms were found to be attacked by an internal malady; this was probably identical with that which proved an important factor in destroying the pest in the succeeding year, viz. a disease caused by a protozoan parasite, *Microsporidium polyedricum*, Bolle. Early records show that there had previously been spontaneous cessation of attacks after the appearance of numerous worms, but until the discovery of the protozoan disease, none of the various insect and bird enemies of the worm had been observed to be sufficiently abundant to cause the sudden cessation of the attacks, in the manner referred to above.

Although it involves a considerable amount of labour, the practice of picking and destroying egg-masses and larvæ, as conducted under Government supervision, has been found generally serviceable.

The method of drowning the larvæ in the ground by irrigation is considered impracticable of application on a large scale.

The efficacy of moth traps is largely discounted by the fact that the female deposits most of her eggs before entering the trap.

The application of external insecticides is ineffective, unless they are used sufficiently strong to destroy the plants as well.

The lack of rainfall renders the use of arsenical and other internal insecticides dangerous to man and animals.

It is considered that the ravages attributed to the cotton worm have been greatly overestimated, and that the boll worms are far more injurious. This is in a large measure due to the circumstance that the cotton worm and the

effects of its activities are readily apparent, whereas the boll worms and their ravages are largely obscured.

Prodenia ornithogalli in the West Indies.—In the West Indies the larvæ of *Prodenia ornithogalli* feed on the roots of the cotton plant and on the stem of the young seedlings. Poisoned bait has proved an effective remedy. The bait is made by mixing 25 lb. of bran (pollard) and 1 lb. of Paris green to a thick paste with water, and adding a sufficient quantity of molasses to sweeten it. This is distributed along the rows when the cotton seed has been planted ; the worms eat the paste and are killed before the seed germinates.

Prodenia eridanii, Cramer, attacks immature cotton bolls in Florida.

THE AMERICAN COTTON WORM.—*Alabama argillacea*, Hübn., the American cotton worm or cotton caterpillar, was considered one of the worst pests of cotton in the United States until the arrival of the boll weevil ; for in cases of severe attack it practically denuded the plants of their foliage. So abundant are the worms at times that they are regularly fed to turkeys and are used as food for pigs.

It is probably a native of Tropical America, but it also occurs in the West Indies, where it is one of the worst cotton pests. So far as is known, the worm feeds solely on the cotton plant. Indirectly it has become an enemy of the boll weevil, for the weevils breed profusely in the fallen bolls and also in the lower bolls on the plant. Under normal conditions such bolls are protected from the sun by the foliage of the cotton plant, but when the leaves are removed by the cotton worm or other agencies, these bolls become heated to a temperature that is fatal to any boll weevil grubs that are present. The removal of the leaves likewise causes the crop to mature earlier, and picking can be completed before the weevils' attack reaches its maximum virulence.

Life-history of Alabama argillacea.—The eggs are small, pale bluish-green, round but flattened-convex in shape, with parallel longitudinal ridges converging at the centre above. They are laid singly, at night, usually on the under surface of the leaves. They hatch in three or four days.

The young larva is at first pale yellow, but soon turns green ; later it has a fine bluish-white line running the whole length of the middle of the back, and when full grown is

1½ inch long. The larval stage is from twelve to fourteen days. It pupates within a portion of a leaf folded over and secured by a few silken threads that form a cocoon.

The pupa is greenish at first, but changes to dark brown. In shape it is nearly cylindrical, but is pointed at the posterior end. It is about half an inch long. The pupal stage lasts about two weeks.

The moth is olive-grey, with a wing-spread of 1½ inch. It flies at dusk and feeds and deposits its eggs in the late afternoon or early evening. It begins to oviposit a few days after emergence, and lays from 300 to 500 eggs. There may be from three to five generations in a season. It hibernates and remains torpid in sheltered situations.

Natural Checks.—As regards natural checks, birds, toads, and lizards prey on the caterpillars and also on the moths. The eggs are attacked by *Trichogramma pretiosa*, Riley. The larvæ are attacked by *Chalcis annulatus* and a species of *Sarcophaga* as internal parasites, and by *Euplectrus Comstockii* as an external parasite. Three wasps, *Polistes annularis*, *P. bellicosus*, and *P. erinitus*, and the ground beetle, *Calosoma calidum*, prey on the larva and pupa.

THE LESSER COTTON WORM.—*Aletia luridula*, Guen., the Lesser Cotton Worm, is common in the West Indies. In habits, appearance, and mode of feeding, it is similar to *Alabama argillacea*, but the larva is slightly smaller, and when full-grown it has a pinkish or reddish tinge. The full-grown larva enters the soil at the base of the cotton plant, and forms an earthen cell in which it passes the pupal stage. The moth has a wing-spread of 1¼ inch, and is dull grey, tinged with pink or red.

THE COTTON LEAF ROLLER.—*Sylepta derogata*, F., the Cotton Leaf Roller, is prevalent in West Africa and India.

Life-history.—The tiny eggs are round and flattened, of a pale green colour, and are laid singly on the under surface of the leaf; they are rather difficult to find.

The larva is pale green; the integument being transparent, allows the intestines to be seen and imparts a dark colour to the central portion from the head to the end of the body. The full-grown larva is an inch long. It is able to spin silk, with which, after having cut a leaf half across near the base, it spins the sides together, forming a cone. Under protection

of this cone, it feeds on the lower epidermis of the leaf, and fills the cone with its excreta. Several leaves are at times spun together and contain several larvæ.

The pupa is shiny brown, about half an inch long, with a sharp point at the posterior end. It is attached by silk inside the curled-up leaf, no cocoon being formed. The whole life-cycle until the moth emerges is thus passed on the leaf, and takes about a month to complete.

The wing-spread of the moth is about an inch, the slender body being half an inch long. It is pale yellow in colour, with black zigzag lines running across transversely.

In Nigeria it has at least three parasites : a small Hymenopteron of the sub-family *Braconidæ* ; a species of Ichneumonid, *Xanthopimpla punctata*, F. ; and a Tachnid fly.

SEMI-LOOPER CATERPILLAR.—*Tarache catena*, Sow., the Indian Semi-looper Caterpillar, defoliates the cotton plant, leaving little but bare branches. The larva is green coloured and about an inch long. The moth is white with lead-coloured markings. It is most prevalent when there is a lack of rain during the growing season, otherwise it causes little trouble.

THE BRONZE BEETLE.—In the West Indies the Bronze Beetle, *Colaspis fastidiosa*, Lefv., likewise feeds on the leaves.

The control measures employed for the boll weevil are effective in the case of leaf-eating insects.

LEAF HOPPERS.—Various grasshoppers and crickets cause damage to cotton plants by feeding on the leaves and cutting off the young seedlings.

In Nigeria the black and green Short-horned Grasshopper, *Catantops vittipes*, is a very troublesome leaf-eater, and the nymphs often appear in enormous numbers in November, and strip the plants of their foliage.

Other grasshoppers of minor importance are *Aularches miliaris*, L., *Chrotogonus* spp., and *Cryptacanthacris ranacea*, Stoll.

Two crickets, *Brachytrypes portentosus*, Licht, and *Gryllus viator*, Kirby, cause minor damage. The former behaves much in the same way as the mole cricket, while the latter attacks young plants.

Where the Jassid leaf hopper, *Chloreta fascialis*, is prevalent, it has been found possible to resist its attacks by planting

hairy varieties of cotton, which are practically immune to this pest.

Locusts are a serious obstacle to cotton cultivation in the Samarkand district of Russian Turkestan. They sometimes damage young plants in Egypt, while in West Africa and South Africa they are at times a serious menace to the crop if swarms arrive when the plants are young.

CUTWORMS.—Various Lepidopterous larvæ attack the young plants soon after they appear above ground; even when the plants are fairly well grown they may be cut off just above the ground by one of these pests. Nearly all of them hide beneath the surface of the ground by day and come out to feed at night. One of the most common of these pests is *Agrostis ypsilon*; others are *Feltia annexa*, *F. malefida*, *Noctua c-nigrum*, and *Plusia rogationis*. Methods of control in use against these pests consist in spreading poisoned bait in the fields before the cotton germinates. Almost any succulent vegetable, leaves, or young grass may be poisoned with Paris green or some similar arsenical insecticide, and scattered about the fields for this purpose. The bran bait already mentioned may also be used.

FLOWER BUD MAGGOT.—In the West Indies a small Dipterous fly, *Contarinia gossypii*, Felt., lays its eggs in the young flower buds, and the larvæ which hatch therefrom feed on the young floral organs and cause the death of the bud. The bracts of attacked buds usually “flare” back instead of remaining closed, and thus indicate the presence of the pest.

The adult fly is very small and is probably rarely seen; the length of the body is only $\frac{1}{25}$ inch, while the wing-spread measures $\frac{1}{8}$ inch. The full-grown maggot is $\frac{1}{12}$ inch long and is yellow or pink coloured. When the buds fall to the ground, the maggots enter the soil to pupate.

Older buds that are attacked sometimes persist and open into a deformed flower, but the pistil and stamens are generally so much damaged that the flower is incapable of forming its fruit.

The pest is apparently influenced by weather conditions, for it is most troublesome in damp seasons, while dry weather and hot sunshine appear to check it. Early planting and clean cultivation serve to check its ravages.

STEM BORERS.—The Indian Stem Borer Beetle, *Sphen-*

optera gossypii, Kerr, occurs in most parts of India, but it is a serious pest in Surat and Berar. The long, white grub of the beetle lives in the stem, burrowing and feeding on the tissues, where it changes to a chrysalis and eventually to a beetle, which bores its way out and then mates and lays its eggs. Attacked plants are readily detected, for affected parts turn yellow and wither.

Another Indian beetle grub, *Pempheres affinis*, Fst., tunnels in the stem and branches, principally in the stem just above the ground. The stem swells, though the plant does not necessarily die, and later breaks off. The grub pupates in the stem and the beetle eats its way out.

In Nigeria the larva of a small, green, metallic-looking beetle enters the stem near the ground, and bores in the cambium to and fro in a very characteristic manner, filling in the tunnel behind itself with pink sawdust-like excreta. Young plants that are attacked do not usually die, but are generally stunted and distorted, with shortened internodes, and produce undersized, imperfect bolls. Older plants that are attacked become sickly and shed their leaves. After boring for 3 or 4 inches in the cambium, the grub proceeds to tunnel straight up in the wood, sometimes for a distance of 12 inches. When it is fed up, it penetrates to the pith cavity, where it pupates, and in due course finds egress as a beetle by boring.

In Tanganyika, *Xanthoxylum* sp., a small black beetle about $\frac{1}{10}$ inch long, is injurious to cotton. The eggs are laid on the top of the root at the point where the stem appears above the ground, and the grub bores its way into the stem and there pupates.

The destruction of affected plants or parts of plants should be practised in each of the above-mentioned cases as a control measure for stem borers.

ROOT PESTS.—In Nigeria, the larva of a Lamellicorn beetle attacks the roots of cotton plants, and the leaves wither, turn red, and fall off. It causes the premature opening of the bolls and ultimately the death of the plant. The roots are decorticated, and an irregular growth of wound tissue may be seen at the junction of the healthy and unhealthy parts. As the pest may remain dormant in the soil, crop rotation should prove a control measure.

Where cotton is planted on land formerly occupied by sugar-cane in the West Indies, the Sugar-cane Rot Weevil, *Diaprepes abbreviatus*, L., often destroys the roots of the cotton plants.

RED MAGGOT.—Damage is caused to cotton plants in the West Indies by the larva of a fly, *Porricondyla gossypii*, Coq., which is known as the Red Maggot. The fly is related to the Flower Bud Maggot, and is too small to be readily recognised. The maggot is about $\frac{1}{8}$ inch long and is a reddish colour. It occurs in the soft cambium and bast regions of the stem and larger branches, causing their death by girdling. Considerable damage is sometimes done, but in relatively small areas. All affected parts should be destroyed by fire.

MITES.—The Leaf Blister Mite or Cotton Woolly Mite, *Eriophyes gossypii*, Banks, attacks all parts of the cotton plant, except the root, in West Africa and the West Indies. It is almost microscopic in size. It causes distortions or gall-like swellings, probably due to the irritation of the tissues in the course of its feeding. The swellings are lined with a thick growth of fine hairs, among which the mites live.

In affected flower buds the bracts are “flared” back exposing the bud, which is often discoloured. Badly distorted foliage results from its attacks on leaf buds. It destroys axillary buds, which prevent the development of the valuable lateral shoots.

The spread of the pest may be checked by disinfecting the seed with a solution of mercury perchloride or by fumigation with carbon bisulphide; but experience has demonstrated that a close cotton season only is required to keep the pest under reasonable control.

Investigations in the West Indies have shown that strains of cotton immune to the attacks of the pest can be bred in the third generation of crosses between immune and susceptible varieties.

Two Red Spiders, *Tetranychus bimaculatus*, Harvey, and *T. Gloveri*, Banks, are destructive cotton pests. The latter is usually troublesome in the West Indies during dry weather. The mite lives on the under surface of the leaves in enormous numbers, and its feeding causes the leaves to dry up. Careful examination of affected leaves discloses tiny mites running about under or among a delicate web. The former causes

damage in the United States estimated at two million dollars in a bad season. It is supported in the cold season by a variety of wild and cultivated plants. The effects of its attacks are decreased plant vitality, leaf and boll shedding.

In Russia the pest is suspected of carrying disease.

Spraying with a contact poison, such as sulphur and lime mixture, clean cultivation, and the destruction of affected plants and the weeds that harbour the pest, are all beneficial control measures.

APHIS OR GREEN FLY.—The Cotton Aphis or Green Fly, *Aphis gossypii*, Glover, is a troublesome pest of cotton in most countries where it is grown. The effects of its attacks are a curling and dwarfing of the leaves, and serious malformation of the plant, for it sucks up the sap of the plant by inserting a long proboscis into the plant tissues. Their small, soft bodies are usually green in colour. Projecting from the back of each insect are two tiny trumpet-shaped tubes, through which they excrete a sweet, sticky substance known as honey-dew. This adheres to the leaves, blocks up the pores, and prevents them from performing their proper functions. Ants are very fond of feeding on this substance.

Life-history.—A colony of these tiny insects may often be observed on a leaf, all of which are wingless. They appear to be stationary, for their mouth parts are fixed into the tissues of the leaf, sucking out the sap.

Asexual reproduction takes place among these insects; the wingless females, and even the young ones, are able to continue producing young for a considerable period without the agency of the males. The offspring are produced alive and are ready immediately to commence to reproduce themselves. Under favourable conditions the colony thus multiplies with extraordinary rapidity. When, however, their numbers are too large for the available food supply, winged females are produced, which fly to other plants and found new colonies, where asexual reproduction is continued.

Occasionally males and oviparous females are produced, and eggs are laid in the ordinary way, for the occasional stimulus of sexual reproduction is essential for the indefinite prolongation of any form of life.

Fortunately their rapid multiplication is checked by adverse climatic conditions and natural enemies. Damp,

cloudy weather appears to suit them best, while dry, sunny weather, storms, and heavy rain are inimical to them. Of their natural enemies, the most important are various Hymenopterous parasites, Syrphid flies, and the Coccinellids, *Hippodamia convergens*, *Coccinella 9-rotata*, *Adalia bipunctata*, *Megilla maculata*, and *Chilocorus bivulverus*.

The only artificial remedy is spraying with contact poison insecticides such as kerosene emulsion and tobacco solution.

THRIPS.—Of the minute insect pests of cotton, thrips, *Heliothrips hæmorrhoidalis*, Burm., and *H. indicus*, Bagn., are some of the most important; they are most prevalent in Egypt, Sudan, North and South America, the West Indies, India, and South Europe.

The adult insects are only 1 mm. long, and have two pairs of finely feathered wings. Usually they rest in small depressions on the leaf, and move about by walking and jumping, though, when disturbed, they fly in a circle round the plant. They are frequently found on the upper surface of the leaves, giving them a characteristically white or silvery appearance. The lower leaves of a plant are usually attacked first. The insects feed by sucking the sap from the leaves, which eventually wither and die; young plants may be killed outright as a result of their attacks.

Eggs are laid in an incision made on the under surface of the leaf. The wingless larvæ that hatch therefrom also damage the plants in a similar manner. After a few days the larvæ crawl down the plant and become quiescent in the soil for a period of about twelve days, when the adult thrips emerge.

In the absence of cotton the insects feed on a variety of wild plants, which enables them to subsist until the following cotton season. The destruction of the cotton plants after harvest, clean cultivation, and stirring the soil to expose the pest in its quiescent stage to the fatal heat of the sun, are all beneficial control measures.

SCALE.—The Black Scale, *Saissetia nigra*, and the White Scale, *Hemichionaspis minor*, are also common pests of cotton, but fortunately they are both controlled to a certain extent by parasites. The contact poison insecticides suggested for Aphis may also be used in this case.

CHAPTER XVII

COTTON BY-PRODUCTS

Cotton-seed oil mills—Protein value of cotton seed—Cotton-seed flour as a diluent for wheat flour—Residual fibres or cotton-seed linters—Linter production in United States—Value of fuzz—Extraction of cotton-seed oil—Utility of oil residue—Cotton-seed cake—Cotton stalks.

SEED and linters are the chief by-products of cotton, and they comprise more than two-thirds of the weight of the crop as it is harvested by the grower. The world's total production of cotton seed is roughly 11 million tons, which is capable of producing some 2 million tons of oil and about 8 million tons of food for cattle or fertiliser for crops.

Fairly ancient records show that cotton seed has been employed for cattle-feeding purposes for very many years. Up till about 1860 most of the seed produced in the United States that was not required for planting was wasted. Large heaps of rotting cotton seed were familiar sights outside the ginneries, and it became necessary, on sanitary grounds, to introduce legislation to enforce the destruction of seed that had accumulated in this manner.

In many cotton-growing countries, where transport is difficult or is too expensive to warrant the export of the seed or the by-products prepared from it, the seed is still wasted or is used as fuel in the ginning factories.

Cotton-seed Oil Mills.—The Chinese and other Asiatic growers of cotton have for many years employed crude mills to grind the seeds; the oil thus obtained being used for illuminating purposes, and the residue given as food to cattle.

In 1785 a demonstration of the crushing of cotton seed and the extraction of oil therefrom was made before the Society of Arts, London, and this is probably the earliest record of attention being devoted to the subject by Western

nations. Although for six successive years the Society offered its Gold Medal to any one who should express one ton of oil from cotton seed and prepare from the residue food suitable for cattle food, the medal was not won.

A small cotton-seed oil mill was established in the United States in 1832, but little development of the industry took place until 1870, when there were 26 mills. In 1900 the number of these mills had increased to 357, and to-day there are about 850 in the United States alone. In 1924 these mills crushed 3,308,000 tons of cotton seed, and produced 130,616,000 gallons of oil and 1,508,000 tons of cake and meal.

Cotton-seed oil is used in the manufacture of edible fats, salad oil, edible cooking oils, and lard compounds. The by-products of the refinement of the high-grade oils, and sometimes the whole of the crude oil expressed from inferior cotton seed, are employed in the manufacture of soap.

Protein Value of Cotton Seed.—The seed furnishes protein, which is a valuable element of food for man and beast; 1000 lb. of cotton seed produces 450 lb. of cotton-seed meal containing 36 per cent protein.

Cotton-seed Flour as a Diluent for Wheat Flour.—Recent investigations have shown that a highly nutritious flour, apparently suitable for human consumption, is capable of preparation from the cotton-seed kernel after the oil has been extracted. Bread made from a mixture of 80 per cent wheat flour and 20 per cent cotton-seed flour shows on analysis about the same proportions of protein and fat as those found in superior quality lean meat.

Cotton-seed flour is said to have been largely used in the United States during the late war, and it was officially recommended by the Government as a diluent for wheat flour and as a substitute for meat. In this connection the principal objection to the use of cotton-seed flour is its colour, which is yellow, and it imparts this colour to bread made from it, even when the quantity used is as low as 5 per cent, but the flavour is said to be in no way impaired.

Investigations are proceeding with the view of discovering some process of bleaching the flour, and should they be successful it is considered that the employment of cotton-seed flour will have an important effect on the cotton-seed

oil industry, and possibly on the question of wheat supplies as well.

Residual Fibres or Cotton-seed Linters.—Even after passing through the ginning process, a considerable amount of cotton seed retains residual fibres, varying from 2 per cent of the seed weight in the case of the lightly fibred Indian cottons to 12 per cent in the case of American Upland and other fuzzy varieties. This residual fibre comprises, in addition to fuzz, lint that has escaped the gins.

In the United States the residual fibres are removed in three stages : 2 per cent, or 45 lb. per ton of seed, is removed as linters by saw-linting machines ; 3 per cent, or 67 lb. per ton of seed, is removed as “ seed lint ” by seed defibrating machines ; while about 12 per cent, or 112 lb. per ton of seed, is removed as “ hull fibre ” by hull-defibrating machines. All these commodities command relatively high prices.

Linter Production in United States.—Linter production in the United States amounts to some 750,000 500-lb. bales per annum. Linters are employed for stuffing mattresses, absorbent cotton, mixing with shoddy, low-grade yarns, felt, paper products, and wadding. As a pure form of cellulose they are employed in the manufacture of gun-cotton, smokeless powder, celluloid, collodion, photograph films, and “ artificial silk ”.

Value of Fuzz.—Although the potential value of fuzz had been long recognised, at first the efforts to remove it gave a defective product owing to admixture with pieces of seed-shell and foreign matter. In 1912 a machine was introduced that successfully separated the fuzz from the decorticated hulls of the cotton seeds produced under the American system of manufacturing cotton-seed oil. More recently a machine has been perfected which removes the fuzz direct from the seed before decortication.

The fuzz removed from cotton seed is used in the manufacture of high-grade papers, explosives, and vulcanised fibre. It is said to fulfil the requirements for the production of cellulose acetate, “ artificial silk ”, and nitro-cellulose powder.

Quite apart from the commercial value of the residual fibres, their removal results in a considerable improvement in the seed for the production of oil and feeding cake.

Extraction of Cotton-seed Oil.—In the British milling

industry it is usual to crush the entire seed, but by the American system of oil extraction the seed is split open in a decorticating machine, the kernel of the seed is extracted, and this alone is employed for the manufacture of oil, feeding cake, and meal.

The kernels are passed between chilled steel rollers and pressed into small thin flakes. These are "cooked" in steam-jacketed kettles; by this means excessive moisture is expelled and the kernel is warmed so that the expression of the oil is facilitated. At the same time the heat coagulates the albuminous portion of the kernel, which prevents its passing into the oil, and instead is retained in the resultant cake.

The cooked kernels are then formed into the shape of a cake, enveloped in camel's hair cloth, and placed in a hydraulic press, where the oil is expelled by high pressure. The crude oil thus obtained is reddish-brown to black in colour, and this is pumped to the refinery. The free fatty acids and black colouring matter are removed in the refining processes, and the bright golden oil results.

Utility of Oil Residue.—The black, greasy refuse of the oil-refining process yields, by further treatment, still other by-products such as glycerine and candle grease, while the pitch-like residue is employed in the manufacture of the black waterproof paper used so extensively for packing various commodities.

Cotton-seed Cake.—Cotton seed for cattle-feeding purposes has been almost entirely replaced by cotton-seed cake or meal; owing to their high fat-content, cotton seeds tend to produce digestive trouble. The comparative values of American Upland cotton seed and cotton-seed cake are as follows:

AVERAGE PERCENTAGE COMPOSITION

	Water.	Ash.	Crude Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Cotton seed . . .	9.4	4.6	19.5	22.6	24.9	19.0
Cotton-seed cake .	7.5	6.2	44.1	8.1	25.0	9.1

When it is well made and in good mechanical condition, cotton-seed cake is regarded as one of the cheapest and

most nutritious foods available for cows. Weight for weight it contains a greater amount of nourishing material than any other concentrated cattle food. It stimulates milk flow and maintains a high percentage of butter fat in the milk. The nutritive value of the cake is naturally less when it is made from undecorticated seed and it is sold at a cheaper rate. Cotton-seed meal is obtained by grinding cotton-seed cake. Cotton-seed husks are likewise used as a cattle food.

Cotton Stalks.—The stalks of cotton plants, after the crop has been harvested, furnish pulp suitable for paper manufacture, although the yield is rather low. As the supply of material for paper-making shows signs of running short, there is a possibility that the use of the stalks for this purpose might benefit both the cotton-grower and the paper industry.

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